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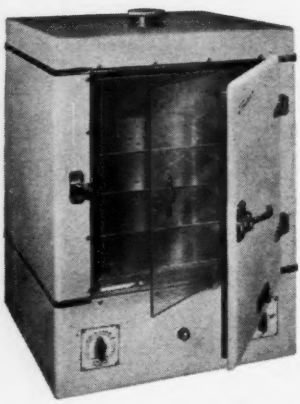

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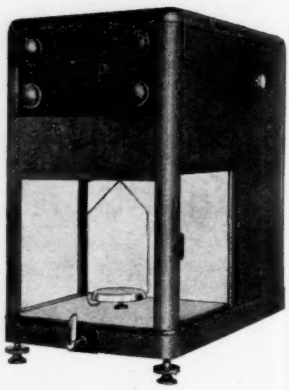

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TECHNICAL EDUCATION IN BRITAIN

SUPPORTED by some notes on technical man-power in the United States, Soviet Russia and Western Europe, and by a report on 'sandwich' training and education from the National Advisory Council on Education for Industry and Commerce, the Government has issued, on the last day possible to redeem its promise, a White Paper on Technical Education*. Apart from the fact that it excludes agricultural education, it is an admirable tract for the times; and the programme it sets forth is accompanied by accounts of technical education in England and Wales and in Scotland which are both readable and put technical education in reasonable perspective in the education system of the country as a whole. The programme includes some sound proposals, but although the White Paper bears evidence of the haste with which it was produced, it is difficult to discover in the plan now outlined any evidence of deep thinking or new initiative that would account for the long delay. On the face of it, this programme could well have been enunciated when the statement rejecting the idea of a technological university was made in December 1954.

As it is, although the way has been cleared to some extent by the further statements made last year regarding technology at the universities and the expansion of the Imperial College of Science and Technology, the piecemeal approach persists. We have still to wait for the universities to produce their plans for technological education for the quinquennium 1957–62, and until these plans have appeared it is impossible to judge how far the £100 million it is now proposed to spend on technical education will go towards fulfilling the Prime Minister's declared intention of January 18 of making good the present shortage of scientists, engineers and technicians.

What needs to be remembered, in the first place, is that the measures now proposed are measures to meet a crisis: they are ameliorative rather than preventive. The White Paper contains fresh evidence of how this sustained piecemeal approach frustrates any effective policy and places obstacles in the way of those who seek to evolve a rational system of education for Great Britain which would eliminate the recurrent difficulties; and not only afford full opportunity to talent of every kind, but also ensure that at every stage facilities exist for bringing out the full potential energy of the population and encouraging its interests in directions that are most desirable socially. There is little in the White Paper to warrant confidence that the nation will get the maximum value from the expenditure now proposed. Indeed, apart from anything else, too much depends on factors outside the Government's control: on the extent to which the co-operation rightly required from the public—from parents and teachers, from the local authorities, from the universities and from industry—is in fact achieved. Government by exhortation has its points, but it has its weaknesses also.

To the extent to which the policy outlined in the White Paper depends on public understanding and support, the Government has been wise to cast it largely in the form of a tract for the times, and to take advantage of the interest which has been aroused of late by comparisons with scientific and technical man-power in the United States and in Soviet Russia such as Lord Simon, Dr. A. V. Bowden, Sir Francis Simon and Sir Solly Zuckerman, and Mr. Nicholas de Witt in his recent book on Soviet professional man-power, have made. Nevertheless, while the White Paper deprecates excessive attention to such comparisons and stresses the circumstances which determine the particular needs of Britain for trained man-power, the magnitude of those needs is not appraised. We are given estimates of the potential supply and the generalized statement that as many as six or seven technicians may be required for one scientist or technologist, but no estimate of the probable demand. It is assumed that useful occupations can be found for all who can be trained.

That may well be true within the proviso that we give sufficient attention, as the White Paper recognizes, to encouraging adaptability and finding a place in technical studies for liberal education. Technical education, it insists, must not be too vocational or confined to one skill or trade, and more attention must be given to the teaching of good plain English, if only to facilitate bridging the gaps that separate experts in different specialized subjects from the general public as well as from one another. Nevertheless, if we are to win the support of parents, they must be convinced that there is every reasonable prospect of a satisfying career open to the boys and girls who enter technical colleges or colleges of technology.

That, of course, is one of the first conditions of success in the first and most difficult step, namely, raising the number of entrants to advanced courses in technology and securing as corollary a sharp reduction in the number of early leavers. It is, moreover, in such qualitative proposals that the White Paper offers most hope of advance, for those proposals could contribute much to the success of a more fundamental and considered long-term policy such as we have yet to see. It attacks, for example, the excessive reliance on evening classes, which are more wasteful alike of students and of staff than day classes, and proposes to double the numbers released for employers for part-time day courses. Similarly, it comes out strongly in favour of the 'sandwich' courses, which Dr. P. F. R. Venables in his recent book regarded as one of the most encouraging signs of the times; and it recognizes the reserve of talent available in modern secondary schools, which is probably best tapped by the technical colleges, as well as that available in girls schools, if girls can be induced to

* Technical Education. Pp. 44. (Cmd. 9703.) (London: H.M. Stationery Office, 1956.) 1s. 6d. net.

seize the opportunities for a congenial career which science and technology can offer.

Beyond pointing to this reserve of talent and stressing the need for rousing the interest and co-operation of parents, the White Paper makes no practical suggestions as to how this is to be achieved. It does, however, make the important proposal that students proposing to attend courses leading to a technological award shall be eligible for Technical State Scholarships, and the number of these Scholarships, which are already available to those employed in industry to enable students of outstanding ability to pursue honours degree courses at universities or elsewhere, will be raised as the capacity of such advanced courses at technical colleges is increased from the present 9,500 to the proposed 15,000. Moreover, to encourage boys and girls to enter such courses straight from school, it is proposed in future to allow State Scholarships awarded on the results of the General Certificate of Education examinations to be held for courses leading to a technological award as well as for honours courses at universities.

Much here is left to the co-operation of the local education authorities in assisting such students with major awards at rates equivalent to those paid to university students, and to the assistance of industry in paying the fees of students attending advanced sandwich courses. The Government is clearly wise to seek such co-operation, but it should be fostered and stimulated as sedulously as possible. More thought might well be given to ways and means than appears on the surface in the White Paper.

It is here, however, that the piecemeal approach is at a disadvantage, and it is with the provision made for expanding the number of full-time or sandwich courses in advanced technology that doubts enter as to the effectiveness of the Government's proposals. The Government proposes that the bulk of the full-time or sandwich courses should be carried on in colleges which concentrate on advanced courses at technological level; and for this purpose it is advocated that, within the five years over which the new grant of £70 million for building and £15 million for equipment is to be expended, the twenty-four colleges at present receiving 75 per cent grant for certain of their advanced work shall divest themselves of work below the advanced level and develop speedily into colleges of advanced technology. It is also contemplated that a few other colleges may qualify for 75 per cent grant, and it appears to be implied in the White Paper that these also may develop into colleges of advanced technology. Indeed, the Minister of Education was pressed specifically in the House of Commons on March 8 to make further provision in the West Riding of Yorkshire and on Tees-side.

It would not appear that by the term 'college of advanced technology' the Government has in mind anything like the Manchester College of Technology or the Royal Technical College, Glasgow; but beyond reference to the fact that the former institution will come under the ægis of the University Grants Committee, there is no indication as to what the distinction is. Moreover, the belief that the Government has not even yet grasped the implications of its proposals is further encouraged by the statement that the part-time advanced courses provided in some one hundred and fifty local colleges conveniently placed for the students and part-time staff who work in industry make, and will be expected to continue to make, a vital contribution to the total output of technologists. In spite of sound definitions of technologists and technicians given in the White Paper, there is little indication that the distinction has been given due weight in the Government's proposals, or that the results of the inquiry into scientific and technical man-power now being carried out by the Technical and Scientific Technical Register of the Ministry of Labour and National Service are likely to be given due weight when they are published later this year. Meanwhile, Sir David Eccles suggested tentatively on March 8 that roughly one-fifth of the £70 million would be required for colleges of advanced technology or for branch colleges to relieve them of less advanced work.

It is not simply that, in the absence of the facts which such an inquiry alone can provide, no sound apportionment of resources of Britain between technical and technological education can be made. Equally important is the question whether we have the resources to establish twenty or thirty colleges of technology, and whether in attempting to do so we may not instead so disperse our resources that most of these colleges will have neither the independence, the status nor the financial resources to enable them to attract staff of the requisite calibre, or students to provide the country with a sound investment from the resources applied. The White Paper admits that regional planning must play a larger part in future if there is to be reasonable economy in buildings and staff, but the Government largely closes its eyes to the inevitable effect on the administration of such colleges.

That the administration of a college of technology is possible in association with local government is shown by the development of the Manchester College of Technology. That example, however, shows the way in which autonomy and civic pride and interest can be reconciled; but it is to be feared that in its reliance on local authorities in this matter the Government is guilty of wishful thinking, just as it is over the National Council for Technological Awards. The folly of refusing to face the facts was clearly shown by Dr. Venables in commenting on regional colleges in his recent book, and the White Paper advances no evidence to suggest that any improvement is to be expected short of placing colleges of technology like the Manchester College of Technology either under the University Grants Committee or, perhaps better still, under a Technological Grants Committee of similar status and powers and possibly charged also with the supervision of technical education in general. Until this is done, the colleges of technology in Britain are unlikely to enjoy either academic autonomy or the status which will enable them to attract teaching staff of high calibre; and even if they have a sufficiently secure financial basis for long-term planning, the local authorities responsible

for the college are likely to be subject to an unreasonable strain of loyalties. Local bodies should not be expected to finance national or even wide regional purposes out of local funds; indeed, as Alderman Barber, chairman of the Bradford Education Committee, has remarked, it is impossible for a local authority, however generous or determined, to ignore the limitations imposed by the amount of rates it can raise.

Dr. Venables's restrained but reasoned argument has been ignored by the Government; and little confidence will be entertained elsewhere in the outcome of the Minister of Education's attempt to induce local authorities generally to establish strong governing bodies widely representative of industry and with powers to spend within the needs of annual estimates approved by the authority. Even if the Ministry of Education possessed the requisite experience, the Minister is not meeting Dr. Venables's point as to the need for a quinquennial or similarly secure long-term basis of planning such as the University Grants Committee supplies—a factor particularly important if the colleges are to develop, as the White Paper suggests, a substantial amount of research, especially research sponsored by industry, or to initiate post-graduate studies. The importance of academic autonomy and status is sadly under-rated by the Government. To bring the colleges of technology under the ægis of a national body of the character of the University Grants Committee, if not that body itself, would do more in a few months to give them the standing and independence which would attract first-class teaching staff than the new award to be given by the National Council for Technological Awards is likely to achieve in many years. Such merits as the latter proposal may possess are long-term in character, and what is needed is, as the Government protests, immediate, if not emergency, action.

But there is another respect in which the White Paper treats the staff issue too lightly. To establish a Technological Grants Committee or to bring the colleges of technology under the University Grants Committee would enable the colleges to compete on more even terms for highly qualified staff and would be far more effective than improved salaries alone. To prune more severely in accordance with material resources the number of colleges to be upgraded to perhaps a dozen or so would also assist, and at the same time ease the difficulty with local government which appears to cause the Government so much concern. Neither step, however, would entirely remove the difficulty over the number of teachers.

This is the weakest spot in the Government's proposals in the White Paper. It is admitted that many more teachers will be required to achieve the objectives set out in the White Paper, and the importance of quality is also recognized. Nevertheless, there is no appreciation that different types of teachers may be required for the technical colleges and technical schools and for the colleges of technology. The existing shortage of science teachers is ignored, and the Government merely expresses the hope that industry will be ready "to release yet more of its employees for part-time teaching during the day, so that its apprentices may be given the more thorough grounding which modern conditions require"; and that by offering the right conditions of service for technical college staff, local education authorities will be able to attract a reasonable share of the available technical man-power.

This is not a policy, and though the White Paper's proposals cannot be fully judged until it is known later in the year what the universities propose to do for technological education over the next quinquennium, it is hard to believe that the proposals now advanced will prove effective in the absence of the measures suggested in regard to academic autonomy and continuity. Pending the results of the inquiry now in progress under the Minister of Labour and National Service, it is to be hoped that the development of further colleges of advanced technology in Britain will proceed with caution, and that more attention will be given to the needs of the technicians. Meanwhile, however, if the organization of sandwich courses is vigorously implemented and also the new proposals for financial aid to students of technology, and if effective measures are taken to secure greater co-operation from industry and the support and understanding of parents, particularly a wider appreciation of the opportunities of careers in technology for girls, substantial steps will have been taken towards better adaptation of at least the functioning of the whole educational system of Britain to meet the nation's needs to-day. But there should also be proceeding a review of the educational system as a whole, qualitatively as well as quantitatively, in which a much more fundamental regard than is apparent in the White Paper is shown, not merely to the nation's needs for trained man-power but also to the purpose of education, to the relations at the different levels and equally to the needs of youth as individuals and citizens, no less than as scientists or technologists, as teachers, as technicians or as craftsmen.

RESEARCH REACTORS IN THE UNITED STATES

Research Reactors

(Selected Reference Material on Atomic Energy.) Prepared by the United States Atomic Energy Commission. Pp. xii+442. (London: McGraw-Hill Publishing Co., Ltd., 1955.) 49*s*.

THE United States Atomic Energy Commission prepared for the Geneva International Conference on the Peaceful Uses of Atomic Energy six volumes summarizing United States work in various fields of atomic energy, of which this handsomely produced book is one. It describes eight of the principal types of research reactors used in the United States, ranging from a 1-W. water-boiler type of reactor to the 30-MW. material-testing reactor in the Idaho desert. Each of the reactors is described, with many detailed drawings and photographs of the reactor and its components. The distribution of neutron flux is given in detail. Very full details are also given of start-up and operating

procedure. Particularly full details are given of the design calculations of the M.T.R. (40-MW.) reactor.

Costs of the various reactors are given, and these vary from 250,000 dollars for a simple swimming-pool reactor to 25 million dollars for the Brookhaven graphite reactor. A detailed analysis of costs for some reactors is provided, and a warning is given that the actual cost depends very much on what buildings and laboratories are associated with the reactor. With this wealth of detail the prospective user may have some difficulty in deciding which type to adopt. In many cases financial consideration will rule out the high-powered more expensive reactors. A reactor in the 10-MW. class will cost £2–4 million and can cost up to £500,000 a year to operate. University users will be limited by cost to reactors of not more than 1 MW. of power. In this class the 1-MW. light-water reactor will probably provide the best compromise between high neutron intensity and moderate price. Its neutron flux of 10^{13} neutrons/sq. cm./sec. makes possible a very wide range of experiments. A flux of 10^{12} is generally considered to be too low for many experimental applications.

The solid-fuel research reactors require a fuel charge of 3–4 kgm. of uranium-235, and this is usually formed into a uranium–aluminium alloy and sheathed in aluminium. The United States has made agreements with many countries to supply research reactors together with 6 kgm. of enriched fuel, the fuel being lent at interest-rates of 4 per cent. Britain is supplying enriched fuel to India, Australia, France and Denmark for research reactors.

Research reactors have become an essential tool of any serious programme for the development of nuclear power, and Britain will soon be equipped with six such reactors, five at Harwell and one at Dounreay. Their use in university research is being seriously discussed at present, and this volume will help those members of university staffs who are concerned.

J. D. Cockcroft

A NEW APPROACH TO BIOSYNTHESIS

Studies of Biosynthesis in Escherichia coli

By Richard B. Roberts, Philip H. Abelson, Dean B. Cowie, Ellis T. Bolton and Roy J. Britten. Pp. xiv+521. (Publication No. 607.) (Washington, D.C.: Carnegie Institution of Washington, 1955.) 2.50 dollars (paper bound); 3 dollars (cloth bound).

FIVE years ago a group of nuclear physicists at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington began an investigation of biosynthetic processes in micro-organisms, making use of radioactive isotopes. This monograph is "a report of research" and represents the achievements to date of these men and their associates. It is an ambitious piece of work: what is presented is a fairly thorough description of the pathways by which carbon atoms from glucose become incorporated into the components of proteins, nucleic acids and lipids of *Escherichia coli* when this organism grows in a simple synthetic medium. A detailed account of the intermediate steps in amino-acid and purine and pyrimidine synthesis is not attempted, but the broad outline of a flow sheet for carbon is sketched both qualitatively and quantitatively. Many of the individual pathways had previously been studied in a range of different organisms under a variety of conditions, but here begins the first attempt to co-ordinate and integrate them in a map of the total synthesis of a bacterium.

The design of the experiments is modest—*Escherichia coli*, growing exponentially in a glucose–ammonia–salts medium, is presented with a tracer labelled with carbon-14 (carbon dioxide, acetate, an amino-acid, or glucose variously labelled) and perhaps some other unlabelled substrate. The pattern of incorporation of radioactivity in amino-acids, nucleotides, etc., is then determined both qualitatively and quantitatively after at least one further generation of growth. From the results of such experiments it is shown, for example, that amino-acids fall into biosynthetic families: serine being precursor to cysteine and glycine; pyruvic acid to alanine, valine and leucine; glutamic acid to proline and arginine; aspartic acid to threonine, methionine, *iso*leucine, lysine and diaminopimelic acid. Similar relationships with minor modifications are found in the yeast, *Torulopsis utilis*, and the mould, *Neurospora crassa*. Histidine and the aromatic amino-acids are not dealt with.

The early chapters are devoted to detailed accounts of experimental methods, fractionation and chromatographic procedures, production of randomly labelled amino-acids by growth of *Chlorella* in carbon-14 dioxide, and permeability studies. Then come chapters on the results of experiments with specific tracers, the variations caused by adaptation to energy sources other than glucose, and the extracellular products of metabolism.

The pathways of amino-acid and nucleotide formation are discussed in the light of the accumulated data, and it is suggested that the Krebs's tricarboxylic acid cycle is involved in the production of intermediates for synthesis rather than for terminal oxidation. A long chapter follows on sulphur metabolism and the roles of glutathione, which contains about one-quarter of the sulphur of *Escherichia coli*, and an alcohol-soluble protein fraction which amounts to about one-sixth of the total protein.

The method of 'isotope competition' is critically examined in the penultimate chapter. This method, which depends on the preferential utilization of exogenously supplied intermediates as compared with endogenously synthesized substances, has been used to gain information about biosynthetic sequences. Thus, when randomly labelled glucose is the major carbon source for growth of *Escherichia coli*, the addition of unlabelled glycine suppresses the appearance of radioactivity in the protein glycine. Addition of unlabelled serine, on the other hand, prevents the appearance of radioactivity in both serine and glycine, indicating that serine is precursor to glycine but not vice versa. Isotope competition has been successfully exploited in the case of *E. coli*, but the method is not invariably applicable; and it is pointed out that its effectiveness is in some cases due to suppression of synthesis by the addition of an intermediate, whereas in others synthesis continues at an unchanged rate but the endogenously produced material is 'swamped' by the exogenous and most of it can (if isotopically labelled) be found in the medium.

The last chapter attempts a quantitative description of the flow of carbon from glucose to cellular components and waste products. One of the tantalizing findings of this work, which in the main so beautifully balances the carbon account, atom by

atom, is that the route of formation of 70 per cent of the total carbon dioxide and 90 per cent of the carbon dioxide derived from C-1 of glucose is unknown. It is suggested that the net output of carbon dioxide from the tricarboxylic acid cycle is less than 3 per cent of the observed production, so that some alternative mechanism must exist for the degradation of glucose to carbon dioxide. Recent findings in other laboratories indicate that a transketolase–transaldolase cycle might be involved.

Thus the report ends with new questions being posed—which is just as it should be. This is an essentially personal account, with five authors whose different styles are apparent but not disconcertingly so. Some readers will challenge the conclusion that the micro-organisms used are freely permeable to ions and small molecules, including hexose phosphates and glutathione, and others will question whether the time is ripe for application, as it were, of Kirchhoff's laws to living organisms. There is little discussion of related findings by other workers using other techniques, but (perhaps as compensation) there is a classified bibliography of well over a thousand post-1940 papers on the biochemistry of *Escherichia coli* and other topics relevant to the text. Two useful appendixes on the kinetics of incorporation and dilution are also included. There is a wealth of illustration, including some thirty full-page reproductions of radioautographs. The text, which is reproduced by a lithographic process, is easy to read and the figures are well drawn, but some, in the chapter on sulphur metabolism, have inadequate legends. The few misprints are mainly confined to tables.

The Carnegie Institution of Washington was founded "to encourage, in the broadest and most liberal manner, investigation, research, and discovery . . .". It is well served by a director such as Dr. Merle A. Tuve, who enthusiastically supports a group of his physicists when they break away into microbiology and when they justify themselves, as in this first major progress report, by writing of "the intense personal pleasure that has come to us in this research".

KENNETH MCQUILLEN

THE HAUNTING OF BORLEY RECTORY

The Haunting of Borley Rectory

By Eric J. Dingwall, Kathleen M. Goldney and Trevor H. Hall. Pp. xiv+181+5 plates. (London: Gerald Duckworth and Co., Ltd., 1956. Published under the auspices of the Society of Psychical Research.) 16*s*. net.

THIS account of the evidence for abnormal happenings in what the late Harry Price described as "the most haunted house in England" well maintains the tradition of the Society for Psychical Research for honest and cautious study of alleged parapsychological phenomena. A heavy task was undertaken at the invitation of the Society by three trained investigators. Their story is at times as interesting as a detective novel; it reveals queer actions of some very curious people; it leaves very little to be explained of the actual haunt itself and a good deal to be puzzled over in the motives, actions and reactions of the people principally concerned. The general conclusion is that credulity, mal-observation, trickery and fraud account for the great bulk of the recorded evidence.

Criticism has been directed against the Society for Psychical Research for having so long delayed an inquiry into Borley Rectory. The relevant facts are these. The case first achieved more than local notoriety in June 1929, when the incumbent, the Rev. Eric Smith, wrote to the editor of the *Daily Mirror* asking for advice as to whom to consult as to the best method of clearing the rectory of its bad local reputation as a haunted house. The results were visits from a reporter and from Harry Price. Articles published in the paper brought crowds of sightseers to the rectory; the situation developed rapidly and was soon out of control. Serious investigation became impracticable, and in any event Harry Price had taken over the case. Two visits were actually paid by Lord Charles Hope, later a member of the Society's council, in July 1929; he came away with the view that the phenomena were produced by normal means and with the suspicion that Harry Price was responsible for some of them. Public interest was maintained, however, by Harry Price sending a rota of (untrained) investigators to report on the haunting and by his two books on Borley Rectory. The Society took up the challenge of this continued publicity in 1949 after Mrs. Eric Smith had written to the *Daily Mail* to express her disbelief in the haunting of the rectory. Price had died in 1948 but his literary executor, Paul Tabori, gave facilities to the investigators to examine his files and correspondence in the Harry Price library. A large part of the case against Harry Price comes from his own writings and papers. Doubts about the genuineness of the phenomena produced in the presence of Mrs. Foyster, wife of a later incumbent of Borley, were also expressed by Price and are strongly underlined in this report.

The destruction of the rectory by fire in 1939 has not ended the story of the haunt, nor the popular interest in Borley. The writers of this book give good reasons why the vague stories of its early haunting and also the more recent accounts need not be taken seriously, and why their report can fairly be taken as "The End of Borley Rectory". The tragedy is that it brings discredit to the name of one who had done so much to bring psychical research to the notice of the general public.

F. J. M. STRATTON

GENETIC RECOMBINATION

Symposium on Genetic Recombination

Given at the Research Conference for Biology and Medicine of the Atomic Energy Commission, Oak Ridge, Tennessee, April 19–21, 1954. (Reprinted from *Journal of Cellular and Comparative Physiology*, Vol. 45, Supplement 2, May 1955.) Pp. vii+321. (Philadelphia, Pa.: Wistar Institute of Anatomy and Biology, 1955.) n.p.

IN the late 'twenties and early 'thirties there was great interest among geneticists and cytologists in attempts to understand the mechanism by which genetic crossing-over takes place. It was believed by many that this would prove a profitable way to attack the problem of gene and chromosome structure. Although several useful working hypotheses were formulated, these hopes were not realized. In fact,

no widely accepted hypothesis consistent with all the facts known about crossing-over in higher forms has yet been proposed. Perhaps one of the most ingenious of the earlier suggestions, especially in the light of the recent proposal of Watson and Crick as to how macromolecules of deoxyribonucleic acid might reproduce, was the one presented by the late John Belling.

In recent years a marked revival of interest in the crossing-over approach has been stimulated by a series of inter-related developments in genetics. Among these is the large body of evidence that pneumococcal transforming principles are deoxyribonucleic acid, the demonstration that genetic information in bacterial viruses is transmitted in the form of this macromolecule, and the realization that the Watson–Crick double helix structure of deoxynucleic acid might well explain how genetic information is replicated.

A symposium on "Genetic Recombination" was held in the United States during April 19–21, 1954, at the Oak Ridge National Laboratory, and this volume consists of sixteen papers summarizing what had been accomplished at the time of that meeting. The subjects dealt with include pneumococcal transformations, transduction and other recombination mechanisms in bacteria; crossing-over in fungi, algæ, higher plants and higher animals; and, finally, the oxygen effect on chromosome aberrations in higher forms. The symposium dealt with, but did not finally answer, the important question of whether the recombination mechanisms in bacterial viruses and higher plants and animals are fundamentally the same. Chromosomes of the latter contain protein as well as deoxyribonucleic acid and are many orders of magnitude larger than the deoxyribonucleic acid helices of viruses. In addition, in a number of higher forms it is known that, in contrast to recombination in bacterial viruses, a single cross-over produces complementary recombination structures. It may therefore be too much to hope that a single mechanism will account for both processes.

Progress in understanding genetic recombination is at present being made so rapidly and requires so much specialized knowledge for its full appreciation that it is difficult for the general geneticist or biologist to keep up to date. Reports of symposia such as the Oak Ridge one are a great help in this respect.

G. W. Beadle

THE NATIONAL GALLERY, LONDON

The National Gallery 1938–54

Pp. 124+20 plates. (London: National Gallery, 1955.) 12*s*. 6*d*. net.

In 1938 the National Gallery, presumably for reasons of economy, ceased to publish a Director's annual report. That practice is now to start again and, in the meantime, the Trustees have issued a most welcome comprehensive survey of the years 1938–54. This is a model of lucid statement. It not only gives a detailed account of those things one expects to hear about—the evacuation of the collection to Manod quarry at the beginning of the Second World War, the acquisitions during the period under review, and the development of a Scientific Department and a Conservation Department—but, in addition, it records activities which annual reports usually take for granted. It explains, for example, the duties of the senior members of the staff—the keepers and assistant keepers—and gives the public some insight into the extraordinarily complicated work involved in compiling catalogues of the standard of those already produced by Mr. Martin Davies and Mr. Neil MacLaren. Before the War a catalogue of the whole collection was available, but the information it contained was too slight to be of very much use to scholars. The detailed catalogues of the British, French, Spanish, Early Netherlandish and Earlier Italian Schools issued during and after the War have, however, set a standard of scholarship which is a model to the galleries of the world. A new general catalogue, which, one hopes, will be of a more lively character than the pre-war edition, is also in preparation.

The report is not only comprehensive, it is also honest. It records in detail the treatment given to every picture that has been restored and cleaned since the Conservation Department was set up in 1947, and reveals the extent to which scientific examination can solve problems which the eye alone can only guess at. The cleaning of Piero della Francesca's "Nativity" has, for example, shown quite certainly that the thin condition of parts of this picture is due not to its being unfinished, as has often been suggested, but to drastic overcleaning in the past. Again, examination of Van Dyck's "Charles I on Horseback" showed that, when it was first relined, the canvas had been cut in two because of its great size. The work of removing previous relinings and restoring the original canvas involved the construction of a special table and the placing of an awning over the studio roof which had not been repaired since the War.

The question of war damage and its repair is one of the two disquieting subjects in the report, the other being the more serious one of lack of funds. Bomb damage put the west wing of the building out of action, and it was decided to instal as soon as possible a badly needed air-conditioning plant which would serve the rooms in this wing as they were re-opened. The plant was installed after delay, and the rooms are gradually coming into use; but even by the end of 1956, eleven years after the end of the War, parts of this block of the gallery will still not be available for the exhibition of pictures. This is the more serious when one realizes that since 1938 the collection has been increased by about a hundred and eighty pictures. A number of these have been transferred to the Tate Gallery, but there have also been transfers to the National Gallery from the Tate. Rebuilding does, however, progress, if only slowly. The problem of the lack of funds available for purchases is more urgent. A national collection, however large, is never complete. There will always be certain pictures which, if they come on the market, should be bought for the National Gallery rather than any other. But the annual government grant to-day, £10,500, stands only a few hundreds higher than it did in 1880. The Gallery has an additional income of about £10,000 from endowments, but with only £20,000 a year available, it is quite unable to compete for masterpieces unless Parliament votes a special grant-in-aid. The need for a very much larger annual grant is undeniable.

This report is not written for the profession only. It is written for all those persons who care for fine pictures, and it should be read by them. It can be strongly recommended.

K. J. Garlick

Cotton Growing Problems

By Prof. Basil G. Christidis and George J. Harrison. Pp. vii+633. (London: McGraw-Hill Publishing Co., Ltd., 1955.) 73*s*.

FIFTY years ago there was not much background of scientific knowledge about cotton in the field, but few crops to-day are better known, so that the biggest problem facing the cotton-grower is how to write a concise account of our garnered knowledge and to expose the gaps in it. The natural starting-point for a grower is the seed, but the first half of this book deals with varieties, crop rotation and soil fertility; then the seed appears, to be followed up through its planting and cultivation.

This lack of balance is also evident in the use of references; there is little discrimination between major studies, minor observations and tertiary oddments.

There are large omissions, notably in the chapter on irrigation, which does not refer to the two volumes of Willcocks and Craig, nor even to my own recent book. The remarkable sixteen-year set of field experiments by D. S. Gracie is not cited until long after Part 3, on fertilization, has been concluded, and then in a line only. There is no hint that the cotton hair is built of growth-rings, that the cotton plant has a root, or that the whole crop of all varieties grown in Egypt is derived and maintained from 'individual selection'. The bibliography includes more than a thousand entries, in spite of omissions, but is difficult to use because it is split into eight separate groups, one for each part of the book, covering sixty-two scattered pages.

Many observations from the Greek cotton research station at Sindos by Prof. B. G. Christidis are quoted, and are evidently comprehensive. I wish that Prof. Christidis could have dealt with this, his first-hand knowledge, in more detail; for the differences of soil and climate found under conditions in Greece can be most illuminating, and a book thus severely localized in its material would have been more generally suggestive in formulating the problems of cotton-growing.

W. LAWRENCE BALLS

The Analysis of Drugs and Chemicals

By Dr. Norman Evers and Wilfred Smith. Pp. xii+546. (London: Charles Griffin and Co., Ltd., 1955.) 60*s*. net.

THE forerunner of this book, by Evers and Elsdon, appeared more than twenty-five years ago and acquired a deserved reputation as a useful book to those engaged in the field covered by the title. Since that time, many new drugs and chemicals have come into general use, only a proportion of which have been included in the "British Pharmacopœia", or the "British Pharmaceutical Codex". The present volume deals with the official drugs and a number of the more important unofficial ones, together with those chemicals which find application in pharmacy. It is in the same form as its predecessor, but has been completely rewritten.

There is no clear-cut classification of the heterogeneous materials used in medicine, and the distinction between drugs and chemicals can only be arbitrary. Nevertheless, some sort of grouping is necessary and this has been appropriately done under the following headings: inorganic chemicals; organic chemicals; natural compounds and their derivatives; fixed oils, fats, waxes and soaps; volatile oils; crude drugs; miscellaneous pharmaceutical materials; and galenicals and other pharmaceutical preparations. These groups are preceded by chapters on general analytical methods, and followed by one on the use of statistics in chemical analysis and by several useful appendixes.

The book is intended to supplement the "British Pharmacopœia" and the "British Pharmaceutical Codex"; it must be used in conjunction with these volumes, since it is rarely indicated whether the substances mentioned, or the tests to be applied, are official or not. When so used, it should prove useful to the advanced student and to those engaged in the examination of named substances. It will be of only limited value to those concerned with unknown substances, for example, the toxicologist; the "of" in the title must not be read as including "for".

J. R. NICHOLLS

College Chemistry

An Introductory Textbook of General Chemistry. By Prof. Linus Pauling. Second edition. (Series of Chemistry Texts.) Pp. xii+685. (San Francisco: W. H. Freeman and Company; London: Bailey Bros. and Swinfen, Ltd., 1955.) 6 dollars; 51*s*.

FOR the new edition of this book Prof. Linus Pauling has revised throughout both the text and illustrations. In the first part the facts, concepts and theories are presented more gradually and factually, and the sequence of chapters altered to provide a more systematic arrangement. Each of the six parts has an introduction describing the chapters in it and explaining why each topic is introduced in the given order. The amount of organic chemistry is increased, and at the end there are two new chapters on chemical substances related to living organisms and one on nuclear chemistry.

Chapter 3 on the electron and nuclei of atoms, in which the subjects are treated historically, is clear and easily understandable. It is followed by one on the periodic law treated on a factual basis, which is then explained on the basis of atomic structure. The descriptions of the preparation and properties of elements and compounds are related as far as possible to atomic and molecular structure. The subject of valency is particularly fully and carefully treated, and much attention is given to the geometry of molecules. The sections on physical chemistry are clear and are introduced in appropriate places. Much use is made of the historical approach throughout the book.

There is no doubt that the book has been greatly improved in the new edition. Many teachers who desire to introduce modern aspects of theoretical chemistry into their courses will find how this can be done without sacrificing fundamental chemistry by a study of Prof. Pauling's thoughtful book.

Rational Approach to Chemical Principles

By Dr. John A. Cranston. Second edition. Pp. xii+231. (London and Glasgow: Blackie and Son, Ltd., 1955.) 10*s*. 6*d*. net.

THIS small book, now in its second edition, evidently fills a need in giving a brief account of the background of physical chemistry of about intermediate degree examination standard. There may be some doubt as to whether it is really rational to introduce quantum numbers before the simple gas equation; but if students are prepared to swallow whole this preliminary summary of atomic structure, the rest is plain sailing. In the present edition, the author has included many more numerical examples in physical chemistry, which no doubt will be found useful, and the book will continue to serve a modest but useful purpose.

J. A. V. B.

THE INTERNATIONAL GEOPHYSICAL YEAR

GEOPHYSICAL STATION AT COATS LAND, ANTARCTICA

By J. M. WORDIE, C.B.E.

THE station recently established by the Royal Society in Coats Land in the Falkland Islands Dependencies will be one of the most comprehensive among the many others now being set up in the Antarctic for the International Geophysical Year. The different sections of the programme are being given full opportunity to develop in whatever direction seems the most promising. Moreover, the station, which is a large one, has been set up not only in an important area, but also in favourable local conditions.

It should be noted, however, that this is not the only British station in Antarctica. There is already a well-equipped geophysical station at the Argentine Islands on the west coast of Graham Land in lat. 65° 15′ S., long. 64° 16′ W. Geophysical work in the Dependencies began in 1948 when ionospheric observations were first made at Port Lockroy. Later, the Argentine Islands base, about twenty miles farther south, was developed as more suitable for geomagnetic and upper-air work in general, and this station is now dealing with solar radiation, ozone observations, and a geomagnetic programme, which began on January 1, 1956. Ionosphere observations, however, continue at Port Lockroy. These two places in combination form an important link in the line of International Geophysical Year stations situated near the 70°–80° W. meridian line. Both are organized and manned by the Falkland Islands Dependencies Survey under the authority of H.E. the Governor, Mr. O. R. Arthur, who has continued the policy of the previous Governor, Sir Miles Clifford.

Apart from this, there will also be subordinate International Geophysical Year stations, mainly for meteorological and glaciological purposes, at Marguerite Bay in South Graham Land; at King George Island in the South Shetlands; and at South Georgia.

The Royal Society's station on Coats Land carries out the suggestion made at the second meeting of the Special Committee for the International Geophysical Year in Rome in September 1954, that a station should be set up on the Antarctic continent in the important area of the inner Weddell Sea. It was not until a year later, however, that a final decision was made by the Society. The chief difficulty had been doubt about navigation conditions in the Weddell Sea and in the waters off Coats Land, and these doubts were not resolved until the beginning of August 1955.

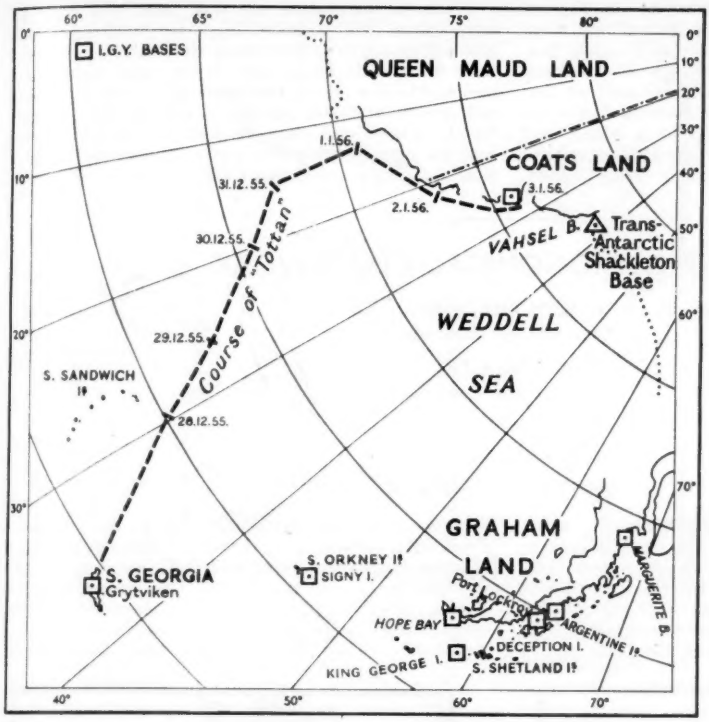
The Weddell Sea has held an ill reputation in the past, but records showed that the ice conditions were adverse only in the western part of the sea, where the pack-ice accumulates in its passage north-westwards. The evidence from Coats Land itself indicated that the Weddell Sea offered no unusual ice difficulties in the eastern and north-eastern approaches. A tongue of pack-ice in the sixties of south latitude stretches eastward from Graham Land. At the eastern end it has been successfully penetrated even by low-powered ships by a route south of the South Sandwich Islands. In January 1912 and again in January 1915 ships broke through to open water; in the case of Shackleton's *Endurance* in 1915, the southern ice edge, reached in lat. 70° S., was found to be separated from the Coats Land ice cliffs by more than a hundred miles of completely open sea. This open water continued as a broad land channel for some 250 miles farther southward along the coast to as far as lat. 76° S. Shackleton took his ship down this land channel partly under sail, running before the wind. This wide open channel was also seen from the air more recently, in December 1951 and January 1952, on flights from the Norwegian base at Maudheim in Queen Maud Land. Both the penetrable tongue and the wide land channel appear to be normal. The secret of entry to the Weddell Sea is to pass through the tip of the tongue in its eastern part and so into land water.

Tentative plans, finally put into operation in August 1955, had already been drawn up for a party of ten men to form an advance unit to erect the living-hut and observing accommodation. There was an early setback as the *Jopeter*, the ship first chartered to carry the party south, was crushed and later abandoned early in September in the ice off East Greenland. The ship selected to replace the *Jopeter*, however, was the well-known *Tottan*, a slightly smaller vessel but with a high reputation for strength and manœuvrability in ice. She has been under the command of Captain Leif Jakobsen, who has had wide experience not only in the difficult ice conditions off East Greenland but also as mate of the *Norsel* in the ice-encumbered waters off Queen Maud Land east of Coats Land. The *Tottan* sailed from Southampton on November 22, little more than three months after the first orders for the hut and equipment had been given. Credit for this speedy carrying out of the Royal Society's plans must go to H.E. the Governor of the Falkland Islands, to the authorities at the Crown Agents, and to Mr. F. K. Elliott, secretary of the Falkland Islands Dependencies Survey.

The *Tottan* reached South Georgia on Christmas Day 1955, and took her departure on December 26, her itinerary being as follows:

December	28	lat. 60° 19′ S.	long. 29° 40′ W.
,,	29	62° 55′ S.	24° 30′ W.
,,	30	65° 25′ S.	20° 00′ W.
,,	31	67° 10′ S.	15° 00′ W.
January	1	70° 30′ S.	13° 10′ W.
,,	2	73° 40′ S.	21° 05′ W.
,,	3	76° 31′ S.	27° 23′ W.

She met pack-ice three days after leaving South Georgia. Penetrating the tongue took about three more days; and she reached open water in lat. 68° S. She had taken a route in about the fifteenth meridian west of Greenwich with very little ice hindrance, which appears to have been easily brushed aside. She then proceeded, just as Shackleton in the *Endurance*, down a great open water channel into the Weddell Sea.



Part of Antarctica showing some International Geophysical Year bases

On January 6 a base site was finally chosen in approximately lat. 75° 28′ S. The exact position has to be confirmed. The *Tottan* was occupied landing the hut and stores until January 22, when she took her departure back to South Georgia on a seven-day return voyage by a slightly more westerly route. There was apparently nothing exceptional in the season, and both in and out voyages confirmed the forecast about the approachability of the Coats Land coast north of lat. 76° S.

Surgeon Lieut.-Commander Dalgleish has described his arrival at the ice cliffs of Coats Land on New Year's Day. Eastwards was the ice-gripped continent fringed with cliffs of ice; but when looking westwards away from the coast it was easy to imagine the ship was in a tropical sea. For two days the *Tottan* steamed along the ice cliffs in an open sea. On January 3 in lat. 76° S., she found herself in much shallower water—as little as 15 fathoms—and had to move away from the coast. Open leads in the pack led her a little way south of lat. 76°, but this was her farthest; and the head of the sea being at that time unapproachable she turned back north to look for a landing place in a lower latitude. Three possible bays were reconnoitred in the neighbourhood of the wide Dawson–Lambton glacier, and landings made at two of them. Conditions of the land-ice at all three places, however, were unpromising. Fortunately, in about lat. 75° 28′ S., a suitable place was finally found. Orders had been given that no station was to be established unless it could be placed south of lat. 75° S. on the Coats Land coast, this northern limit being set by the knowledge that the area of maximum auroral frequency lies farther south. The place chosen seems to fulfil all the necessary conditions, and is described as completely satisfactory for the scientific programme. It is almost certainly Shackleton's "excellent landing place" described by him in 1915 as Glacier Bay; it has now been named Halley Bay (see p. 606 of this issue).

Dalgleish describes two ice headlands, two miles apart, converging to an apex, where an easy slope gives access to the ice sheet. The ice sheet is considered grounded, and no exposed rock was visible. From the top of the slope there was a gentle rise of 5 ft. per mile to the east. The main continental plateau was about thirty-five miles distant. The base is 1½ miles from the slope and is either on "a low piedmont or a grounded ice-shelf". No evidence of any activity or ice movement was noticed at the base site.

Unloading began on January 6. Conditions were easy for tractors, but the work had to be done mainly at night to avoid the slush. It was now high summer and eleven days of sunshine enabled more than two hundred tons of stores to be taken to safety on the hut site.

About five thousand Emperor penguins were found on the fast-ice in an adjoining bay and must indicate the persistence of similar conditions year after year. A few days after arrival the sea ice on which the penguins had been nesting broke up and the penguins went out to sea. They are expected to return to their nesting site at the end of March and beginning of April, by which time the sea will have begun to freeze.

With Surgeon Lieut.-Commander Dalgleish there are three scientists, Major G. Watson, R.E.M.E., Dr. Stanley Evans and Mr. D. Limbert. During the present reconnaissance year the observations at the base will be on a limited scale. In meteorology, apart from daily observations, a Dobson ozone spectrophotometer will be in use for the first time in high latitudes. There will be no work in geomagnetism, and the magnetic hut is not due for erection until January 1957. Auroral observations will begin using an 'all-sky' camera which has been specially modified by Mr. James Paton. This consists of a mirror and a camera which takes a picture of the sky every minute and gives a complete record of auroral displays. The only ionospheric work to be undertaken this present year will be measurements of atmospheric noise. Glaciology will not be prominent in the reconnaissance year, nor will seismology or gravity.

The latest reports from the Royal Society base are that the skeleton of the hut is in place, but that it will take about two months before the roof and the side walls are complete. Since the *Tottan* left on

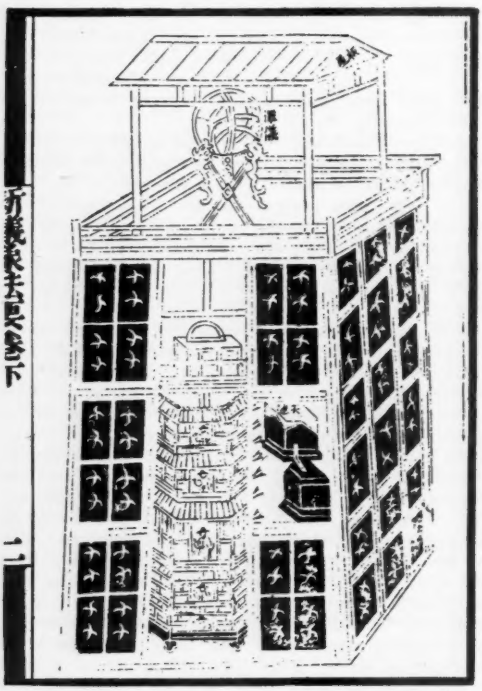
January 22, the base has been visited by the *Theron*, Dr. V. E. Fuchs's Trans-Antarctic Expedition ship, on her way south to the head of the Weddell Sea. Dr. Fuchs called again on February 8 after setting up his own base on the Filchner Ice-shelf at lat. 77° 57′ S., long. 37° 16′ W., about twenty-five miles west of Vahsel Bay. In due course it is hoped that an overland route will be established between the bases, which are more than two hundred miles apart.

Plans for the future are that next year the two expeditions will share a large ice-breaking sealer. She will go south in November 1956 carrying eighteen men for the International Geophysical Year party and eighteen men for the Trans-Antarctic party, and will arrive at Coats Land in January 1957. There will be a brief visit by a relief ship in January 1958; and the geophysical party is due to leave the Weddell Sea in January or February 1959 to return to Britain.

CHINESE ASTRONOMICAL CLOCKWORK

By Dr. JOSEPH NEEDHAM, F.R.S.
Caius College, Cambridge
WANG LING
Trinity College, Cambridge
AND
Dr. DEREK J. PRICE
Christ's College, Cambridge

IT is generally agreed that the invention of the mechanical clock was one of the most important turning-points in the history of science and technology. According to the view accepted until recently[1-4], the problem of slowing down the rotation of a wheel to keep a constant speed continuously in time with the apparent diurnal rotation of the heavens was first solved in Europe in the early fourteenth century A.D. Trains of gearing were then combined with the verge and foliot escapement and powered by a falling weight. Recent research has shown, however, that these first mechanical time-keepers were not so much an innovation as has been supposed[5]. They descended, in fact, from a long



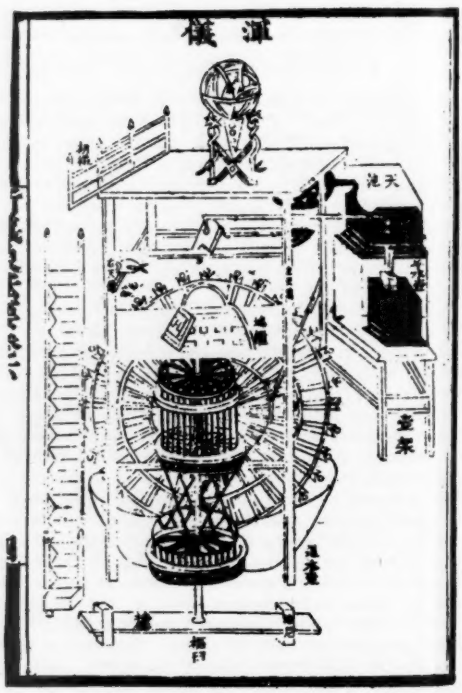


Fig. 1. Astronomical clock of A.D. 1088 from Su Sung's "Hsin I Hsiang Fa Yao", ch. 3, p. 2*a*. External appearance. The armillary sphere on the platform above, the celestial globe in the upper chamber of the tower, and the pagoda with the time-announcing jacks below this. On the right, the housing removed to show the water-tanks. Estimated total height about 30 ft.

Fig. 2. The same as Fig. 1. General view of the works. Vertical shaft with jack-wheels in the foreground, behind this the driving-wheel with its scoops. Water-tanks on the right, part of the anti-recoil device on the left at the top. Escapement not shown in this diagram, though the device above the wheel is probably intended for part of it

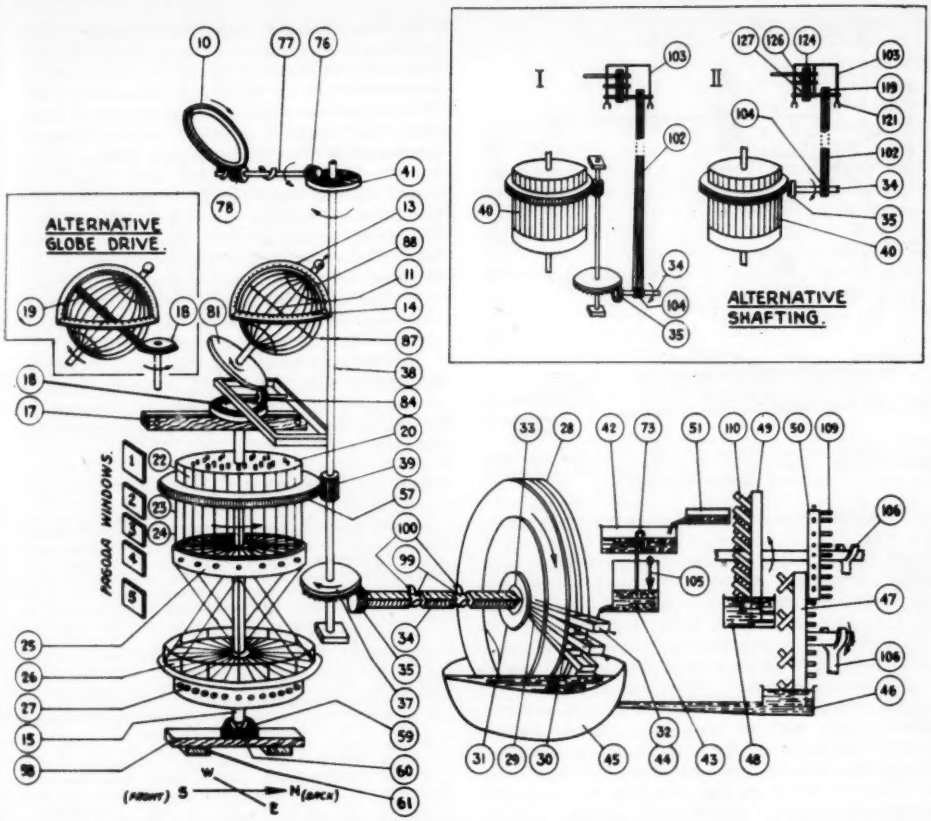


Fig. 3. General reconstruction. The numbers indicate technical terms which will be given and explained in the full publication. Gearing at the top of the jack-wheel shaft on the left drives the celestial globe. The long shaft rotating the armillary sphere was in later models replaced by successively shorter chain drives, as shown in the inset. On the right are the two norias which raised the water to the uppermost reservoir, sufficient for twenty-four hours running. (*Drawn by Angel*)

series of complicated astronomical 'clocks', planetary models, mechanically-rotated star-maps and similar devices designed primarily for exhibition and demonstration rather than accurate time-keeping. Although such devices are of the greatest interest as the earliest complex scientific machines, it has not hitherto been possible to adduce more than a few fragmentary remains, and literary descriptions tantalizingly incomplete, which lack sufficient detail for clear understanding of the mechanical principles involved. But the examination of certain medieval Chinese texts, the relevance of which has not been realized, has now permitted us to establish the existence of a long tradition of astronomical clock-making in China between the seventh and the fourteenth centuries A.D.

The key text is the "Hsin I Hsiang Fa Yao" [New Design for a (Mechanized) Armillary (Sphere) and (Celestial) Globe], written by Su Sung in A.D. 1090, the appropriate sections of which we have fully translated. This describes in great detail an astronomical clock of large size (Figs. 1 and 2) powered not by a falling weight, but by a scoop-wheel using water or mercury. Besides the rotation of the sphere and globe by trains of gear-wheels, the clock embodied elaborate time-keeping jack-work. The escapement consisted of a weigh-bridge which prevented the fall of each scoop until full, and a trip-lever and parallel linkage system which checked the rotation of the wheel at another point. An anti-recoil device was also built in. The basic principle involved is thus more like the anchor escapement of the late seventeenth century than the verge and foliot type, although the time-keeping is, of course, governed mainly by the flow of water rather than by the escapement action itself. This type of effect is therefore the 'missing link' between the time-keeping properties of a steady flow of liquid and those of mechanically produced oscillations. So complete is the description, which has yielded more than a hundred and fifty technical terms of eleventh-century mechanics, that it has been possible to prepare detailed working drawings of the clock (Figs. 3 and 4).

The full understanding of this text has enabled us to interpret many descriptions of other clocks contained partly in the dynastic histories and partly in other sources, some from books now lost, but preserved in the "Yü Hai" encyclopædia of A.D. 1267. Thus an important astronomical clock driven by mercury was built by Chang Ssu-Hsün, a Szechuanese, in A.D. 979. The tradition seems to start with an instrument completed in A.D. 725 by the Tantric monk, I-Hsing, and an engineer named Liang Ling-Tsan, the description of which would not have been

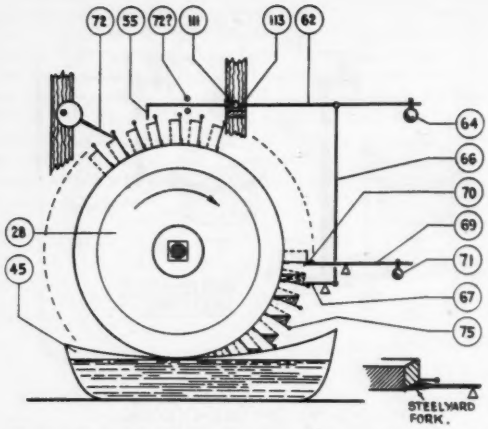


Fig. 4. Diagram of the escapement, with its weigh-bridge and parallel linkwork. The clepsydra flow delivered into the scoop at 70. (*Drawn by Angel*)

comprehensible without thorough prior study of Su Sung's text.

Earlier texts describe celestial globes or demonstrational armillary spheres rotated by clepsydra water. These range from the work of Chang Hêng about A.D. 130 to that of Kêng Hsün about 590, but evidence of any escapement is absent. We supposed at first that these employed only the sinking float of a large clepsydra. This was the system of the Hellenistic anaphoric clock with its rotating astrolabic dial[6], and perhaps also of the famous striking water-clocks of the Byzantine[7] and Arabic[8] culture-areas. But textual and historical considerations incline us rather to the view that the clepsydra water dripped on to a scoop-wheel, turning a shaft with a trip-lug which constituted a pinion of one. This acted on a toothed ring on the apparatus, moving it tooth by tooth.

It thus appears that the Chinese tradition of astronomical clockwork was more nearly in the direct line of ancestry of the late medieval European mechanical clocks. Moreover, the detailed description of this previously unrecognized type of water-driven clock has made it possible to find similar devices incompletely described (perhaps because incompletely known) in Indian[9], Arabic and Hispano-Moorish[10] texts. Of the transmission of influences little can as yet be said, though there are indications that the European centuries just preceding the fourteenth knew devices with water-powered and mechanically checked driving-wheels[11]. This would suggest that the time of transmission was rather that of the Crusades (as in the case of the wind-mill) than that of the Pax Tartarica and Marco Polo.

All the texts now translated, with commentary and discussion, will, it is hoped, be published as a special monograph by the Antiquarian Horological Society, to which the results of the investigation have been communicated.

[1] Beckmann, J., "A History of Inventions, Discoveries, etc.", vol. 1, pp. 340 ff. (Bohn, London, 1846).
[2] Usher, A. P., "A History of Mechanical Inventions", pp. 191 ff., 304 ff., 2nd edit. (Harvard Univ. Press, Cambridge, Mass., 1954).
[3] Frémont, C., "Origine de l'Horloge à Poids" (Études Expérimentales de Technologie Industrielle, No. 47; Paris, 1915).
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NUCLEIC ACIDS AND PROTEIN SYNTHESIS

In recent years it has become increasingly evident that the nucleic acids play an important part in cellular metabolism, and the general interest in the recent developments in this field was well demonstrated by the size of the audience which attended the Biochemical Society's symposium on "The Structure of Nucleic Acids and their Role in Protein Synthesis". This meeting was held at the London School of Hygiene and Tropical Medicine on February 18 last.

In opening the morning session, which was concerned mainly with recent chemical and physical evidence about the structure of the nucleic acids, the chairman, N. W. Pirie (Rothamsted Experimental Station), defended the work of P. A. Levene, which of recent years has been criticized for obscuring the issue by over-simplification. He also suggested that some suitable word should be coined to embrace the terms 'purine' and 'pyrimidine'.

The first paper in the symposium was given by Dr. R. Markham (Agricultural Research Council Virus Research Unit, Molteno Institute, Cambridge), who outlined the discoveries which have been made in the past ten years and which have more or less revolutionized ideas about the structure and the complexity of the nucleic acids. Much of his talk was devoted to a discussion of the degradative approaches which have led to the picture of nucleic acids as straight-chain molecules made up of nucleoside residues linked by 3′ : 5′-phosphodiester bridges. He also emphasized the importance of the hydroxyl group at C′2 as a part of the structure of ribonucleic acids which might be involved in the biological transformations of the molecules, and he pointed out that its absence in deoxyribonucleic acids has precluded a chemical investigation of the latter by methods which have proved so successful in the study of the ribonucleic acids. The deoxyribonucleic acids have, however, been found to have structural regularities; but he doubted whether the self-replicating mechanisms which have been postulated recently by various workers will fit all the experimental observations.

In discussion, Dr. F. H. C. Crick outlined a scheme by means of which he believed these difficulties could be overcome. He also doubted whether the less

common purines and pyrimidines have any real biological significance.

The second paper of the morning session was given by Dr. M. H. F. Wilkins (Medical Research Council Biophysics Unit, King's College, London), who described some of the elegant X-ray crystallographic work which has come from King's College, London, and which has been responsible for our present conception of deoxyribonucleic acids as double helices. He pointed out that the X-ray data indicate that the molecule has two grooves of unequal depths, and that in the nucleoprotamines the polypeptide chains lie inside these grooves, the non-basic amino-acid residues occurring in pairs so as to be able to loop away from the main helix. The data obtained with nucleohistones are not so easily interpreted, but they suggest a substantial amount of orientation of the protein on the nucleic acid molecules.

Dr. Wilkins deplored the current tendency of physicists to explain the relationship between nucleic acids and protein synthesis by numerological arguments, and suggested that, among other things, certain of their premises are faulty. This evoked a reply by Dr. Crick, who pointed out that the number of amino-acids in each protein has been found to be essentially the same, namely twenty, if a few minor suppositions are made.

The afternoon session, with Prof. J. N. Davidson (Biochemistry Department, University of Glasgow) in the chair, was concerned with the relationship of the nucleic acids with protein synthesis; he introduced the session with a general survey of the present knowledge of the various sub-cellular elements and the problem of their isolation.

The study of protein synthesis in higher organisms was discussed by Dr. B. A. Askonas (National Institute for Medical Research, London), who described the use of radioactive tracers to follow amino-acid incorporation into proteins in various cell fractions. A particularly suitable system for this kind of experiment is to be found in cells synthesizing protein in response to a specific stimulus such as occurs in immunological reactions. It is, however, difficult to obtain results of this type with sub-cellular preparations, and it is necessary in such cases to follow the labelling of various fractions isolated by physical methods. Fractions rich in nucleic acid are found to have most activity.

Dr. E. F. Gale (Medical Research Council Unit for Chemical Microbiology, Cambridge) described some of the recent work which he has carried out on disrupted *Staphylococcus aureus* suspensions, following the incorporation of labelled amino-acids. Deoxyribonucleic acid is a powerful stimulatory substance and loses its activity on hydrolysis. Ribonucleic acid is not so active, but on enzymic degradation becomes very active indeed. The identification of the various factors influencing the incorporation of specific amino-acids with specific polynucleotides has, however, been found to be incorrect, and it appears that specific substances of unknown nature are liberated when the nucleic acid is broken down.

In comment, Dr. W. E. Cohn remarked that nucleic acid preparations may yet prove to contain substances of which we have no knowledge at present.

The bacteriophage–bacterium system was the subject of the last paper in the session, which was given by Dr. K. Burton (Medical Research Council Cell Metabolism Research Unit, Oxford). This system is of particular interest in view of the injection of virus nucleic acid which is known to take place on infection; but it was pointed out that a not inconsiderable amount of protein is also introduced at the same time into the bacterium. In the case of the *T* even bacteriophages which parasitize *Escherichia coli*, it is actually possible to follow the synthesis of bacteriophage nucleic acid because of the presence of a specific pyrimidine, 5-hydroxymethyl cytosine, in the latter, and it is certain that study of this system will be of great importance in the future. Results obtained so far, however, do not seem to fit with any simple replication mechanism of the types which have been proposed.

The meeting ended with a general impromptu discussion of template mechanisms involving nucleic acids. Although the general tenor of the symposium was somewhat speculative, the interest of the audience and the many questions raised in discussion showed that the choice of subject was a good one, and the Biochemical Society and its symposium organizer, Dr. E. M. Crook, are to be congratulated on the success of the meeting.

OBITUARIES

Prof. W. C. McC. Lewis, F.R.S.

With the death of William Cudmore McCullagh Lewis on February 11, Britain lost one of its finest physical chemists. After graduating with distinction at the Royal University of Ireland in 1905, he carried out research work at the Universities of Liverpool, Heidelberg and London and was appointed lecturer of University College, London, in 1910. The best-known of his many early researches were his experimental verification, with F. G. Donnan, of the Gibbs adsorption isotherm and his theoretical treatment of the Joule–Kelvin effect. These two substantial advances have long since found their way into standard text-books. In 1913 Lewis was appointed to the Brunner professorship of physical chemistry at the University of Liverpool, a chair which he held until his retirement in 1947. He was elected a Fellow of the Royal Society in 1926.

During his first decade at Liverpool, Lewis led an active school in experimental studies of chemical kinetics. The most notable single publication in a long series of papers on catalysis is his "Calculation in Absolute Measure of Velocity Constants and Equilibrium Constants in Gaseous Systems" (1918). Not all the conclusions of this paper have proved to be correct. It is now known, for example, that diatomic molecules do not dissociate by a first-order mechanism, and that activation generally is not by direct interaction with the radiation field. These, however, are points of detail in comparison with his main conclusions, which are that velocity coefficients in gaseous systems can be treated by the methods of statistical mechanics and that in certain examples the rate of chemical change is simply the rate of molecular collisions multiplied by the fraction of the total number of molecules which have sufficient

energy. Trautz had independently come to the same conclusion in 1916 but, on account of the First World War, the *Zeitschrift für anorganische und allgemeine Chemie* was not available to Lewis, and both can claim equal credit for their outstanding contribution. The Trautz–Lewis collision theory gave a very considerable impetus to the study of chemical change.

In collaboration with Blair Bell, Lewis led, in the early 1920's, another active team of physical chemists in cancer research. This circumstance probably explains why, like Arrhenius before him, he later transferred his research interest to biochemical and physiological problems.

Lewis is most widely known as the author of "A System of Physical Chemistry", a graduate text-book in three volumes which went into four English editions in nine years. To the task of preparing it he brought the experience of a skilled experimentalist, the wide learning of one conversant with many foreign tongues and the sympathy of one accustomed to teach. His book reveals a breadth of outlook which is not entirely unexpected from one familiar with the methods of research of so many different universities; there is in it no vestige of the narrowness so often found in books written by those who teach only where (and often only what) they were taught. His book is by no means perfect. At the time of its appearance the character of physical chemistry was rapidly changing, and the author must have worked exceptionally hard to keep abreast with the many developments of that period. As things turned out, material which Lewis had to put in an appendix to his third volume appears in the introductory passages of modern text-books. Despite its shortcomings, however, his text-book exerted a wide influence and can truly be described as the first original treatise of advanced physical chemistry in the English language.

Nature had endowed W. C. McC. Lewis not only with a brilliant intellect but also with magnificent physique, so that the reflexion of most men on meeting him was that here was a grand type of man. The dignity of his appearance was heightened by his impeccably correct bearing and mellifluous voice. The frequent gleams of humour in his eye and flashes of Irish wit in his utterances saved him from being ponderous or pompous. He was an extremely retiring man and abhorred publicity. His attendance at public scientific gatherings averaged one in twenty years. He made lasting friends of those whom he taught, and proved himself to be throughout his career a great scientist and a kind man.

E. A. Moelwyn-Hughes

Dr. Harold King, C.B.E., F.R.S.

Dr. Harold King, a former member of the scientific staff of the Medical Research Council, died suddenly at his home in Dorset on February 20 at the age of sixty-eight.

The son of a schoolmaster, King studied chemistry at Bangor under K. J. P. Orton and in 1911 published, with Orton, his first group of papers, on the chlorination of aromatic compounds. From Bangor he moved for a few months to a company of tar distillers at Beckton, but, finding the atmosphere uncongenial, he accepted in 1912 an appointment with Burroughs Wellcome. Here he came into contact with F. L. Pyman, G. Barger and H. H. Dale, and acquired his abiding research interest in the chemistry of pharmacologically active compounds. In 1919, King was asked to join a small group of workers who were to establish the reputation of the new National Institute for Medical Research at Hampstead; here he remained for the rest of his working life.

A man of quiet and retiring disposition, King preferred his laboratory bench to all other attractions, and his gradual emergence as a scientific figure of international repute seemed almost to surprise him. Early contributions on hyoscine, muscarine and the cinchona alkaloids were followed, in 1924, by the first paper of a long series on trypanocidal arsenicals. While no outstanding new drug was synthesized during these investigations, there emerged a much fuller understanding of the relationship between constitution and trypanocidal action, and eventually, in collaboration with the late Warrington Yorke and E. M. Lourie, King developed an entirely new group of chemotherapeutic drugs, the diamidines.

Although probably the most active British chemist of his generation in chemotherapy, with many contributions on trypanocides, antimalarials, amœbicides and on the chemotherapy of virus infections, King's interests ranged over a much wider field, and his most outstanding contributions were in the field of the chemistry of natural products. In 1935, he published in *Nature* a brief note on curare, followed by a masterly series of papers extending over fourteen years in the *Journal of the Chemical Society*; in these he reported methods for the isolation of pure curare alkaloids; he also provided complete proof of the structure of *d*-tubocurarine and related alkaloids and clarified the botanical problem of the origin of the different curares. Moreover, he stimulated work at the National Institute on the polymethylene di-quaternary ammonium salts, simple analogues of tubocurarine, now in general therapeutic use as the well-known methonium compounds.

In 1932 also, King, together with the late Dr. O. Rosenheim, suggested a new structural formula for the steroids, which was quickly accepted as an outstanding clarification of the field, and made possible the rapid progress which followed in elucidation of the structural relationships of the sex hormones and the cardiac aglycones.

Although he did not welcome administrative responsibility, Dr. King was for many years an efficient secretary to the Chemotherapy Committee of the Medical Research Council, and during the War, secretary also to the Committee for Penicillin Synthesis. In 1933, he was elected to the Royal Society, and in 1941 was awarded the Hanbury Medal of the Pharmaceutical Society.

One additional publication deserves special attention, since it relates to King's activity outside the laboratory; in 1946 he read a paper to the South London Entomological and Natural History Society on the "Sex-attractant Principles of Moths". Few men can have derived such constant pleasure from their hobby as did King from his collection and study of British moths. No colleague could regard himself as a friend until he had been privileged to examine that collection, and no other subject could thaw King's natural reserve in the same way. Perhaps this collection showed his true character more clearly than any scientific paper; a lover of order, peace and beauty, King was a true naturalist. Those of us who passed through his laboratory as junior colleagues will always remember him with affection, not only because he was helpful, but also because of his

likeable personal idiosyncrasies, his determination to do things for himself, his staunch insularity and his refusal to discourage or disparage the ideas of his juniors, however wild those ideas may have seemed to a man of his scientific insight.

Dr. King married in 1923 Miss E. M. Croft and is survived by her and his one son. T. S. WORK

Dr. Robert M. Yerkes

THE death occurred on February 5 of Dr. Robert M. Yerkes who, for well over fifty years, played a dominant part in the development of animal psychology and, in particular, the study of the behaviour of apes and monkeys. Yerkes graduated in 1899 from Harvard University, where he was given his first teaching post. In 1917, the year the United States entered the First World War, he left to become professor of psychology and director of the Psychological Laboratory at the University of Minnesota. During the course of this appointment he became special adviser on the selection of officers to the Armed Services, and chairman of the Research Information Service of the U.S. National Research Council. He also held a number of other official advisory appointments, and in 1921 became chairman of a Committee on Problems of Sex that was set up by the National Research Council. This body, of which Yerkes continued to be chairman until 1947, was highly influential in developing the study of reproductive physiology and of endocrinology.

Yerkes will be best remembered for his studies of the behaviour of apes; his own research interest was mainly in the question of intelligence and ideational behaviour. His first big monograph on the subject, entitled "Mental Life of Monkeys and Apes", was published in 1916. The work for which he is best remembered was done after 1924, when he was appointed professor of psychology at Yale University. It was during this phase of his career that Yerkes established and organized the Yale Laboratory of Primate Biology at Orange Park, Florida. This Laboratory specializes in work on chimpanzees, and has been responsible not only for most of the behavioural studies that have been made of apes, but also for much of the information we have about their reproductive physiology.

In 1929 Yerkes published, in collaboration with his wife, Ada W. Yerkes, a monumental work called "The Great Apes". This book immediately became, and remains, a source book of information on almost all aspects of the apes except their anatomy. In 1943, shortly before he retired from the active direction of his department at Yale, Yerkes published another book under the title "Chimpanzees: a Laboratory Colony", which is also the authoritative work in its field. S. ZUCKERMAN

NEWS and VIEWS

Industrial Metallurgy in Birmingham: Prof. E. C. Rollason

PROF. E. C. ROLLASON, at present Henry Bell Wortley professor of metallurgy in the University of Liverpool, has been appointed to the chair of industrial metallurgy in the University of Birmingham in succession to Prof. A. J. Murphy, who has been appointed principal of the College of Aeronautics (see *Nature*, **176**, 55; 1955). Prof. Rollason has distinguished himself in both university work and industry. He took his M.Sc. degree at Birmingham in 1932 and gained his first experience of teaching at the County Technical College, Wednesbury. Returning as senior lecturer to the Department of Metallurgy in Birmingham in 1935, he carried out research which led to the Ph.D. degree, and contributed to the development of teaching methods in the Department. At the outbreak of war, Prof. Rollason was seconded to the firm of Murex Welding Processes, Ltd., to pursue researches on the welding of armour plate and other important defence problems. In 1942 he accepted the post of research manager; he later became a director of the Company, and played an important part in building up the Research Department. Prof. Rollason returned to academic life in 1951 when he was appointed to the chair of metallurgy at Liverpool, where he has devoted himself to the reorganization of the laboratory training and the development of the undergraduate and postgraduate schools. Prof. Rollason has taken an active part on the Research Board and committees of the British Welding Research Association, and is the author of many papers on the metallurgy of stainless steel, metal spraying, and the welding of ferrous and non-ferrous metals, as well as of a successful text-book, "Metallurgy for Engineers".

Millport Marine Station, Scottish Marine Biological Association: Mr. E. Ford

MR. E. FORD is retiring from the joint post of director of the Millport Marine Station and secretary to the Scottish Marine Biological Association, which he has held since 1949. Previously the secretaryship had been a part-time post not held by the director of the Station. At the same time as Mr. Ford was appointed, the Association took under its auspices the Oceanographic Laboratory at Edinburgh and, in his capacity as secretary, Mr. Ford became responsible for both laboratories. He successfully achieved the formidable task of administration involved in the organization of the Association's office at Millport, from which the affairs of both laboratories are controlled. During the seven years of his directorship at Millport, Mr. Ford has been responsible for major developments, and the Station has become a research institute of major importance. Much of the research accommodation has been rebuilt and enlarged, the library reorganized and a workshop and stores erected. With aid from the Carnegie Trust of the Universities of Scotland, a new aquarium has been erected and a new classroom is now just completed. The scientific staff has increased, and a second research vessel has been acquired.

Dr. C. H. Mortimer

DR. C. H. MORTIMER, who succeeds Mr. Ford, has been for some twenty years a member of the staff of the Windermere Laboratory of the Freshwater Biological Association, reaching the grade of senior principal scientific officer. After graduating in zoology from the University of Manchester, Dr. Mortimer took a research degree at the University of Berlin. His first work was on cytology and repro-

duction in *Cladocera*; but after appointment to Windermere his interest moved to the physical and chemical aspects of organic production in freshwaters. He has carried out notable research on the exchange of dissolved substances between mud and water and more recently on water movements. This has carried him as far afield as Lake Michigan in the United States and Loch Ness in Scotland. There is much in his approach to the problems of water movements and fertility which is common to freshwaters and the sea. His change, therefore, from the one type of aquatic research to the other is natural and should prove highly productive.

Royal Geographical Society: Medals and Awards, 1956

H.M. The Queen has approved the award of the Royal Medals of the Royal Geographical Society as follows: *Patron's Medal:* John Giaever, Norwegian Polar Institute, leader of the Norwegian–British–Swedish Antarctic Expedition, for contributions to polar exploration; *Founder's Medal:* Charles Evans, leader of the Kangchenjunga Expedition 1955, for contributions to Himalayan exploration.

The Council of the Society has made the following awards: *Murchison Grant:* Dr. Alice Garnett, for contributions to physical geography and geographical education; *Mrs. Patrick Ness Award:* Robert Dovers, Australian National Antarctic Research Expedition, for contributions to Antarctic exploration and mapping; *Gill Memorial:* R. A. Skelton, superintendent of the Map Room, British Museum, for studies in the history of cartography and exploration; *Back Grant:* Richard Hamilton, senior scientist, British North Greenland Expedition; *Cuthbert Peek Grant:* David Oates, Fellow of Trinity College, Cambridge, for archæological surveys in Iraq.

Imperial Chemical Industries Transfer Scholarships

With the aim of increasing the number of university science graduates, Imperial Chemical Industries, Ltd., is to provide annually over the next few years about fifty scholarships of a new type, designed to enable students who have not specialized in science at school to commence serious study of science at the university itself. To be known as I.C.I. Transfer Scholarships, they will make it possible for students to take a preliminary science course of one year's duration at certain universities, and then go on to take normal honours science courses. The scholarships will be available for the first time during 1956–57 at the University of Cambridge; Imperial College of Science and Technology, London; King's College, Newcastle; the University of Liverpool; and the University of Oxford. The value of the scholarships will be based on State Scholarship rates, and there will be continuing small awards to scholars who successfully pass on to take honours science courses. The scheme has the full support of the Ministry of Education and of the universities and colleges concerned. Imperial Chemical Industries believes that these scholarships will help to solve one of the major problems of present-day industrial Britain—namely, the training of a greatly increased number of scientists and technologists. There are many young men who have taken arts courses at school and done well in them, but who, on going forward to the university, may wish to specialize in science subjects rather than taking advanced work in arts. At present they are not able to do this, for unless they have studied science at school they are unable to enter honours schools of science and technology in English universities. The scholarships are expected to produce 40–50 additional scientists or technologists per year, but that will be only a part, and probably a small part, of their influence if they serve to encourage a wider provision of elementary science courses in the universities.

Royal Society Antarctic Station at Halley Bay

All the authorities concerned have agreed to a recommendation of the Council of the Royal Society that the bay in Coats Land, Antarctica, in which the advance party of the Royal Society Antarctic Expedition for the International Geophysical Year, led by Surgeon Lieutenant-Commander D. Dalgliesh, landed from the M.V. *Tottan* on January 6, be called Halley Bay; and that the site of the hut, which is 1½ miles inland from the coast, be known as Royal Society Base (see p. 598 of this issue). Edmond Halley was a former secretary of the Royal Society, and this year is the tercentenary of his birth. His scientific work made pioneer contributions to many of the subjects which will receive further concentrated observation during the International Geophysical Year. Thus he studied the theory of the Earth's magnetic field, and in 1698 and 1700 made two voyages to the North and South Atlantic Ocean, which resulted, in 1701, in the publication of the first magnetic chart. His further studies enabled him to realize that the aurora borealis is associated with the Earth's magnetism. He discussed with much care the problem of trade winds, which were very important to the sailing ships of his day, and carried out some fundamental work on ocean currents, and noticed the variation of gravity as he approached the equator.

Department of Scientific and Industrial Research Bill

The Department of Scientific and Industrial Research Bill (London: H.M.S.O. 6*d*. net), issued simultaneously with the Department's annual report for the year 1954–55, and which received its first reading in the House of Lords on March 20, proposes to replace the present Advisory Council for Scientific and Industrial Research by an executive Council, referred to in the Bill as the "Research Council". The body, like the present Advisory Council, will comprise persons eminent in industry and in science, but will in future be in executive charge of the Department, subject to the over-riding responsibility of the Committee of the Privy Council for Scientific and Industrial Research and of the Lord President of the Council as its chairman. The Bill also provides in a specific Act of Parliament for the expenditure of the Department to be met out of moneys provided by Parliament, and the Imperial Trust for the Encouragement of Scientific and Industrial Research is accordingly dissolved. There appears to be nothing in the Bill which provides specifically, however, for financing the work of the Department other than on a year-to-year basis. The present annual report, while noting an increase of £260,000 in the net estimate of the Department for 1955–56 compared with 1954–55, records a failure to maintain the annual rate of increase in staff of two hundred required by the five-year plan. Some concern is expressed about the work of the research associations, more particularly in the smaller industries, and the

advantage of linking the research association serving such an industry with an established and related research association serving a larger industry is emphasized. Confidence is none the less expressed that during the past five years the research association movement as a whole has demonstrated its strength and vitality and that most of British industry believes firmly in the value of its research associations.

Awards for Advanced Courses at Technical Colleges

In a written answer on March 15 to a question in the House of Commons, the Minister of Education, Sir David Eccles, said that during 1953–54, the latest year for which figures are available, 9,829 awards were obtained by students of advanced courses at technical colleges. Of these, 237 were internal degrees in science and 209 internal degrees in technology at the University of London; 722 external degrees in science and 283 external degrees in technology; 110 associateships of the Royal Institute of Chemistry; 248 Higher National diplomas; 6,940 Higher National certificates; 350 college diplomas (technical); and 90 college diplomas (science).

Agricultural Research in Scotland

In a written reply on March 9 to a question in the House of Commons, the Secretary of State for Scotland, Mr. J. Stuart, said that eight institutes for agricultural research in Scotland are financed by the Department of Agriculture for Scotland and administered by independent governing bodies under the general scientific guidance of the Agricultural Research Council. Expenditure on agricultural research for the current financial year amounted to £875,800, of which £140,050 was capital expenditure; on agricultural education to £362,300, of which £148,300 was capital and £159,000 maintenance expenditure on agricultural colleges, and £55,000 on farm schools; and on agricultural advisory services to £537,400. These figures take no account of expenditure at Scottish universities on agricultural education met by the Universities Grants Committee.

Projected Giant Radio Telescope in Australia

In 1954 the Carnegie Corporation of New York offered the Australian Commonwealth Scientific and Industrial Research Organization 250,000 dollars towards the construction of a giant radio telescope for its Radiophysics Division, subject to the provision of sufficient further funds from other sources. Since then the Australian Commonwealth Government has promised to pay half the cost of the project, and further private donations have been received including a second 250,000 dollars from the Rockefeller Foundation. These generous contributions are sufficient to permit the construction of an instrument, and arrangements have been made with the London firm of consulting engineers, Freeman, Fox and Partners, to undertake a design study. In this work they will be assisted by Dr. B. N. Wallis. Details of the instrument will depend on structural factors and available finance; but the broad specification is for a steerable reflecting telescope of the maximum feasible aperture which will work without deterioration in performance down to a wave-length of 21 cm. (the atomic hydrogen spectral line). A corresponding instrument, of 250-ft. aperture, is nearing completion at Jodrell Bank in England, and the construction of others is contemplated in the United States; but this is the only one projected for the southern hemisphere. It will be invaluable in completing the coverage of the whole sky, and, with this in mind, the International Astronomical Union and the Royal Astronomical Society have each expressed themselves as strongly favouring the project.

Natural History of Coral Atolls

During the American atom-bomb tests in the Marshall Islands in 1946, known as 'Operation Crossroads', comprehensive investigations on the geology, ecology and oceanography were carried out not only at Bikini atoll where the weapons experiments took place but also, as controls, at the neighbouring atolls of Eniwetok, where the ecology had been somewhat disturbed by wartime military operations, and at Rongerik and Rongelap, which had scarcely been touched by the outer world. The studies were continued by expeditions in 1947 and 1950, when the geological structure at Bikini was explored by several diamond-drill holes, and when seismic refraction and aerial magnetic surveys were made over this atoll, an adjacent guyot and the surrounding sea-floor. The conclusions of the large team of workers engaged in this project have lately been published by the United States Geological Survey (Professional Paper No. 260, 1955; parts *A–R*, 684 pp., 218 text figs. and 224 plates). Along the submarine slopes of Bikini and of the nearby seamount, specimens of olivine-basalt, basaltic ash and basic volcanic tuff were dredged from depths of 1,000–2,010 fathoms (6,000–12,060 ft.), providing the first direct evidence of the volcanic nature of the base on which a coral atoll is built. In the deepest borehole (2,556 ft.) the coral reef was not bottomed, the strata penetrated consisting entirely of fine detrital limestones, in composition almost a pure calcium carbonate, all originally deposited in lagoonal waters not less than 30 fathoms in depth. The oldest sediments reached are of (?) Oligocene age. Seismic refraction studies have confirmed and extended the results of drilling by indicating that several thousand feet of relatively unconsolidated calcareous rock overlies a volcanic core with a highly irregular topography. Unlike the borings undertaken at Funafuti atoll (to a depth of 1,114 ft.) in 1896–98 and at North Borodino (1,416 ft.) in 1934–36, the drilling at Eniwetok (1,285 ft.) and Bikini (2,556 ft.) has yielded cores of limestone rock which is quite free from dolomitization. It is a measure of the intensity of the collecting carried out during the recent surveys that more species of corals are now known from Bikini atoll than from anywhere else in the world.

Animal Husbandry

The sixth holder of the Devon County Agricultural Association Lectureship endowed at Seale Hayne Agricultural College was Prof. J. E. Nichols, of the University College of Wales, and in his series of four lectures on "Animal Husbandry", given during 1954–55 and now published (pp. 40. Newton Abbott: Seale Hayne Agricultural College, 1956; 4s.), he deals with general principles and then the particular problems of beef and dairy cattle, sheep and pigs. His final lecture is concerned with the methods and aims of to-day and to-morrow. In the first two lectures he gives particular attention to the sequences of change in bodily form and function in relation to nutritional requirements and to costs: to the interacting factors which affect beef and milk production

and, in particular, the need for cowmanship. In his third lecture the differences in husbandry arising mainly from fertility-rates are discussed with respect to sheep and pigs, and in his final lecture an attempt is made to bring the present and the immediate future into perspective. Prof. Nichols points out that intensive management is best reserved for the phases during which intensive production takes place in order to reduce wastage of stock and conserve feed resources. In general, intensive conditions—whether they refer to housing, to feeding, to control or to stockmanship—are most needed and are best applied to the peak periods of lactation, to before and just after parturition, and again to the finishing period of bacon, pork, mutton and beef. So far as cattle are concerned, as part of the requirements for intensification, the simple point of dehorning comes into the picture; in itself it enables saving in space as well as of energy to be made.

Soil Science in New Zealand

The New Zealand Society of Soil Science held its first conference, under the presidency of Mr. N. H. Taylor (director of the Soil Bureau, N.Z. Department of Scientific and Industrial Research), as Section M of the eighth New Zealand Science Congress at Auckland in 1954. The proceedings have now been published (N.Z. Soc. Soil Sci., 54 Molesworth Street, Wellington, N.Z.; pp. 32; 4*s*.), and the presidential address issued as a reprint from the *Transactions of the Royal Society of New Zealand* (**82**, 961; 1955; 1*s*.). In his address, "The Role of Soil Science in New Zealand Problems", Mr. Taylor discussed the subject under four main headings: problems arising from the interdependence of land use and society, and from the use of soils for engineering purposes, for the growing of plants or for the support of animal life. Practical examples mentioned are the selection of the most suitable sites for urban development, road foundations and pipe-line corrosion, while on the biological side are questions of irrigation and forestry or the relationship between soil and the incidence of dental caries. During the conference, symposia were held on forest soils, the aims and values of soil analyses and on the pumice soils. Full summaries of the papers read on each occasion are published in the proceedings, together with the discussion that followed. Shorter abstracts are given of the papers contributed at other sessions.

Automatic Recording of Temperature and Vapour Pressure or Dew-point

In normal measurements of the humidity of the air near the surface, readings are taken of dry- and wet-bulb temperatures, and the vapour pressure, dew-point and relative humidity are calculated from tables. For automatic recording there are available the thermograph, giving a continuous record of dry-bulb or wet-bulb temperatures, and the hair hygrograph, giving a record of relative humidity. Again, the vapour pressure and dew-point have to be calculated from tables. To study the water economy of plants, continuous records of vapour pressure and dew-point are needed, and to obtain these Dr. U. Berger-Landefeldt, of the Technical University of Berlin, has devised an automatic electrical recorder which he describes in the December issue of *Weather* (**10**, 405; 1955). Continuous readings of wet- and dry-bulb thermometers are made and are arranged by suitable circuits to solve the hygrometric formula and give continuous records of dry-bulb temperature, vapour pressure and dew-point. Records obtained by the instrument are shown in the article, and it is explained how the large variations in vapour pressure of 8 mm. of mercury are due to the vigorous transpiration of the alfalfa plants over which the instrument was placed.

Formation and Properties of Diamonds

In a paper entitled "Diamant" (*Zprávy Výzkumného ústavu pro minerály v Turnově*, **4**, 577+33 figs.; 1955; Czech, with Russian, English and German summaries), Dr. Primus Ružička offers an explanation of the formation of diamond by the reaction $2CO \rightarrow CO_2 + C$ under great pressure, the pressure finally building up enough to break through the sedimentary rocks and emplace the pipes of kimberlite. He employs this theory to link up a number of observations: sharp octahedra and holohedral forms crystallized more slowly and at lower pressures than rounded crystals, which mostly belong to the ditesseral polar (blende) symmetry class. Type II diamonds crystallized slowly at a lower pressure than type I; and the lamellar structure common in type II diamonds is due to the intercalation of layers of a graphite or 'pseudo-graphite' structure. Bort is regarded as a late product, formed during and after the emplacement of the kimberlite. An explanation of the differences, particularly in crystal habit, between diamond from different localities is offered. In the final sections (pp. 91–114), the anisotropy of the hardness of diamond is discussed, particularly in connexion with the industrial applications of diamond.

Earthquakes during February

During February the greatest earthquake was of magnitude 7¼, and had its epicentre south of Honshu, Japan, with depth of focus 450 km. Earthquakes of magnitude between 6 and 7 occurred on February 1 in the Marianas Islands; on February 9 and later, aftershocks in Lower California; on February 12 and later, aftershocks near the north-west coast of Luzon, Philippine Islands; and on February 19 in the Queen Charlotte Islands. A shock on February 1 in the Fiji Islands had a depth of focus of 600 km. The swarm of shocks, with the principal one on February 9, in Lower California (epicentre south of the point 32° N., 116° W.) did minor damage in the Imperial Valley and at San Diego, and many of the shocks were felt in Los Angeles. Of this swarm, twenty-nine shocks greater than magnitude 5 occurred during February 9–17, and according to the seismological laboratory at Pasadena the later epicentres were somewhat to the east of the principal one. On February 14 an earthquake with its epicentre near the east coast of Honshu caused several injuries and minor property damage in Tokyo. Its magnitude was 5¾ and depth of focus 60 km. On February 15 in Peru an earthquake was responsible for two deaths in the Callehon Huaylas region, while on February 20 in Turkey an earthquake at Eskisehir caused extensive property damage and was responsible for the deaths of four people; many others were injured.

Open Days at the Atomic Energy Research Establishment, Harwell

The Atomic Energy Research Establishment at Harwell was founded ten years ago, and, to mark the occasion, a series of 'open days' is to be held in the week ending June 2. On the first four days, members of both Houses of Parliament, correspondents of the British, Commonwealth and foreign

Press and representatives of the neighbourhood will be invited to tour the establishment. On June 1 there will be a 'university open day', when scientists and technologists from universities and Government research establishments and representatives of industry will be invited. As a result of the changes in security classification made before the International Conference on the Peaceful Uses of Atomic Energy at Geneva last year, much of the work at the Establishment is no longer subject to security restrictions. Consequently, visitors will have more freedom to see a wider range of work at Harwell than was possible until recently.

Society of Chemical Industry : Seventy-fifth Annual Meeting

In connexion with the seventy-fifth annual meeting of the Society of Chemical Industry, which will be held in London during July 9–14, a series of lectures will be given under the title of "Achievements of Industrial Chemistry". They will be introduced by Dr. L. A. Jordan on July 11, speaking on "Modern Methods of Research", and thereafter they will fall into two parallel series. The first series, under the title of "Products of Industrial Chemistry", will be as follows : new products of the fermentation industry, by J. J. H. Hastings (July 12) ; hydrocarbon macromolecules, by C. W. Bunn (July 12) ; carbohydrate macromolecules, by Prof. M. Stacey (July 13) ; nitrogen- and chlorine-containing macromolecules, by Prof. H. W. Melville (July 13). The second series will be on "Tools of Industrial Chemistry", and will be as follows : metals as plant construction materials, by Dr. N. P. Inglis (July 12) ; non-metals as plant construction materials, by Herbert W. Cremer and G. Brearly (July 12) ; manufacturing techniques, by W. d'Leny (July 13) ; records and control, by Dr. G. M. Dyson (July 13).

The Night Sky in April

New moon occurs on April 11d. 02h. 39m., U.T., and full moon on April 25d. 01h. 40m. The following conjunctions with the Moon take place : April 4d. 05h., Mars 4° S. ; April 11d. 17h., Mercury 4° S. ; April 14d. 14h., Venus 4° N. ; April 19d. 19h., Jupiter 6° N. ; April 27d. 05h., Saturn 3° N. In addition to these conjunctions with the Moon, Venus is in conjunction with Aldebaran on April 14d. 20h., Venus 9·1° N. Mercury is too close to the Sun in the first half of the month for observation, but after that it can be observed in the evening ; its time of setting on April 30 is 21h. 25m., which is two hours after sunset. Its stellar magnitude varies from −1·2 to 0·2, and the visible portion of its illuminated disk from 0·880 to 0·460 ; its distance from the Earth is 125 and 85 million miles on April 1 and 30, respectively. Venus sets at 23h., 23h. 35m. and 23h. 40m. at the beginning, middle and end of the month, respectively, its stellar magnitude varying between −3·9 and −4·1, and its distance from the Earth between 75 and 54 million miles ; the visible portion of the illuminated disk varies from 0·570 and 0·401. Mars rises at 3h., 2h. 35m. and 2h. on April 1, 15 and 30, respectively, stellar magnitude 0·7–0·3, the increase in brightness being due to the distance from the Earth decreasing from 121 to 98 million miles ; at the beginning of the month it lies a little south of λ Sagittarii, and its eastward movement is easily detected by observing its positions with reference to this star over a few nights. Jupiter is visible throughout the night, setting in the morning hours at 4h. 20m., 3h. 20m. and 2h. 20m. on April 1, 15 and 30, respectively. Its stellar magnitude varies from −1·9 to −1·7 owing to its distance from the Earth increasing from 435 to 457 million miles. Saturn rises at 23h. 05m., 22h. 05m. and 21h. at the beginning, middle and end of the month, respectively ; its westward movement can be noticed by comparing its positions during the month with β and ν Scorpii, and its stellar magnitude varies from 0·5 to 0·3 owing to its distance from the Earth decreasing from 866 to 839 million miles. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich : April 2d. 4h. 08·4m., 21*G* Sgr. (*R*) ; April 17d. 23h. 13·1m., 1 Cnc. (*D*) ; April 19d. 0h. 28·5m., 60 Cnc. (*D*) ; April 21d. 23h. 03·4m., ε Leo. (*D*), *R* and *D* referring to reappearance and disappearance, respectively. The Lyrid meteors attain a maximum about April 21, but moonlight will make their observation very difficult.

Announcements

Dr. Alexander Muir, head of the Pedology Department, Rothamsted, and the Soil Survey of England and Wales, has been appointed deputy director (Soils Division) of Rothamsted Experimental Station in succession to the late Dr. E. M. Crowther.

The following appointments in the University of London have been announced : Dr. E. G. Healey, lecturer in zoology in the University College of Wales, Aberystwyth, to the University readership in zoology tenable at Bedford College ; Dr. D. C. Spanner, lecturer in plant biophysics at the Imperial College of Science and Technology, to the University readership in botany tenable at Bedford College.

The University of Leeds has appointed Dr. H. C. Versey, reader in applied geology, to a personal chair in the Department of Geology. Dr. P. Padget has been appointed Oppenheimer Geological Fellow in the Institute of African Geology of the University.

The annual general meeting and conference of the Mammal Society of the British Isles will be held in the Zoology School of the University of Cambridge during April 6–9. On April 6, at 8.30 p.m., a public lecture on "The Mammalian Placenta" will be given by Prof. J. D. Boyd, professor of anatomy in the University. Further information can be obtained from the conference secretary, K. M. Backhouse, Department of Anatomy, St. Bartholomew's Hospital Medical College, Charterhouse Square, London, E.C.1.

The Institution of Mechanical Engineers has recently established a set of lectures for boys, to be called the Leonardo da Vinci Lectures, and the first three will be given on April 9, 10 and 11 (at 3 p.m.) as follows : "Fundamental Energy", by Prof. D. G. Christopherson (professor of mechanical engineering, Imperial College of Science and Technology, London) ; "Applied Energy", by Sir Claude Gibb (chairman and managing director, C. A. Parsons and Co., Ltd.) ; and "Nuclear Energy", by Sir Christopher Hinton (member for engineering and production, United Kingdom Atomic Energy Production). Tickets (which are free) for one or more lectures and further information can be obtained from the Secretary, Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

Erratum. In the article "Polar Wandering" in *Nature* of March 24, on p. 551, col. 2, par 2, the second quotation should begin with the word "We" in line 10.

AGRICULTURE IN THE UNIVERSITY COLLEGE OF THE GOLD COAST

By Prof. JOHN PHILLIPS

THE Cocoa Marketing Board of the Gold Coast, with the approval of the Government, has made available to the University College of the Gold Coast the sum of £1 million for the purpose of establishing and endowing an Agricultural Research Station in the Forest Region. Of this amount, the sum of £750,000 has been allocated for investment for staffing and other recurrent expenditure likely to be associated with the proposed Station, while the sum of £250,000 is to be available over the course of the next four years for purposes of capital development.

At a ceremony at the Agricultural Research Station of the Department of Agriculture of the College, at Nungua, near Accra, a cheque for £750,000 and one for £40,000 as the first contribution toward capital needs were presented by the chairman of the Cocoa Marketing Board to the Principal of the University College on February 28.

Briefly, the objectives of the proposed centre, which is to be established in an area of forest on soils considered to be typical of a large area of the forest region, include: (1) Provision of educational facilities for students of agriculture—undergraduate and senior. (2) The investigation of problems in the management of forest soil, including the possibilities of improving on existing practices in 'shifting cultivation' or 'bush fallowing' and the enhanced production of food and commodity crops both annual and perennial. (Among the commodity crops would be cocoa, coffee, cola, citrus, banana, pineapple—and by some special arrangement relating to site, aspects of oil palm production.) (3) Through studies both at and beyond the centre, the gathering of information relating to the economics of production of selected commodity and other crops, with emphasis on cocoa. (4) Study of problems of production, within the forest region, of poultry, pigs and sheep in certain circumstances. (5) Application of special techniques in the removal of woody growth and the cultivation of forest soil—bearing in mind the dangers of extensive and prolonged exposure of these soils to insolation and heavy and consistent rainfall. (6) The organization of a centre on which professional advisory service of a non-routine nature relating to forest agriculture could be based. (7) Establishment of a centre at which scientific and other research workers concerned in the problems of forest agriculture could work, on invitation, from time to time.

The proposed Station is a logical successor to the first research centre established by the University College in 1952 at Nungua, on the Accra Plains, for students of agriculture and for research into the classification and development of soils; crop production under irrigation and on rain-fed land; animal production and pasture management; aspects of soil and water conservation; mechanization of agriculture and agricultural management and economy. The progress at this Station has been sufficiently encouraging to attract the interest of the authorities to an extension of the University College's activities to the most important economic region in the country, that of the mixed evergreen forests.

The University College is in special relationship with the University of London in respect of academic standards, examinations and the conferment of degrees. At the present there are eleven men reading agriculture in the first, three in the second and three in the final year of the agricultural course proper. Special scholarships for men reading agriculture at the College are offered by the Cocoa Marketing Board and the Agricultural Development Corporation of the Gold Coast. A wide range of research by members of the staff is in progress.

THE ART OF SCIENCE

PROF. L. C. BEADLE'S inaugural address, "The Art of Science", which he delivered on October 28, 1954, at Makerere University College of East Africa, Kampala, Uganda, on taking up the chair of biology there, and which has now been published*, is a brilliant exposition of the thesis that every educated person should know something of the history of science and of the nature of creative research. No summary can do justice to an address which abounds in humour, in sense and frank avowals of the author's convictions, but which can scarcely be quoted without distorting the balance of his argument. He starts by insisting that the inclusion of a subject in the curriculum of a university cannot be justified solely on grounds of utility and that no one can fully understand the nature of science without some knowledge of its history. He pauses in his survey of the history of science to observe that the medieval conception of science as a finite body of established facts is exactly what science is not, and to comment that so far there has been a sufficient number of practising scientists in the teaching profession to frustrate the attempts made during the present century to revive the conception through the invention of examinations. Turning to the biological sciences, he points out that the main creative act in biological research is the decision as to what the problem is, and then the posing of the right questions; he does not believe that the biologists can entirely avoid considering the problem of mind and body. If, however, the great progress now being made, with the aid of new techniques, in the physiology of brain and nervous system, on one hand, and in the study of animal behaviour, on the other, leads to the two streams meeting at any point, there should be results of great practical value, and the combined streams might be deep enough for the psychologists and philosophers to navigate.

In dealing finally with the question, "What is the art of science?", Prof. Beadle remarks that the first and greatest exponents of the scientific method,

* The Art of Science: an Inaugural Address delivered at Makerere University College of East Africa, Kampala, Uganda, on October 28th, 1954. By Prof. L. C. Beadle. Pp. iii+32. (London: Oxford University Press, 1955.) 3s. 6d. net.

Bacon and Descartes, though themselves creative thinkers, apparently misunderstood the true nature of creative work. Both seem to have missed the point that scientific discovery is primarily a matter of intuition, that is to say, it is an art. The most essential feature of a creative scientific thinker, Prof. Beadle insists, is his power of imagination and intuition; and knowledge and experience, such as can be got from formal education, are the background from which spring those imaginative flights which are the essence of scientific discovery. He suggests that the greatest single need for the scientific development of Uganda is that the young children should be encouraged, more than they are, to play and experiment. It is the task of the schools to preserve the experimental and imaginative outlook and to protect it against the pernicious influence of examination syllabuses; and it is the task of the universities, the demands of which determine so much the teaching syllabuses in schools, to frame their demands so as to encourage the schools to teach real science, and also to send them teachers who really understand what science is.

EFFECT AT GROUND-LEVEL OF GAS FROM A CHIMNEY-STACK

THE determination of the maximum concentration at ground-level of gas emitted from an industrial chimney-stack is an important problem in the application of meteorology to health. Sutton[1] showed that the concentration at ground-level downwind from the chimney of gas at the same temperature as the surrounding air drifting out of the top rises to a maximum with distance from the chimney and then falls off. He gave a formula for the maximum concentration in terms of wind speed, height of chimney, the atmospheric turbulence coefficients and the atmospheric stability. Usually, the gas is hotter than the surrounding air and has an appreciable vertical speed at the top of the chimney. Both factors cause the gas plume to have a vertical component of speed for some distance from the chimney. The centre line of the plume gradually bends over to become horizontal along the wind at a great distance from the stack.

Recently, Dr. A. C. Best[2] has examined, with the view of helping the stack designer, the relative merits of the following three formulæ for finding the maximum concentration at ground-level of gas from a heated elevated source: (*a*) an extension of Sutton's 'cold' gas formula; (*b*) a theoretical one due to Bosanquet, Carey and Halton[3]; and (*c*) an empirical one suggested in the United States at the Atomic Energy Station, Oak Ridge[4]. Sutton's 'cold' gas formula is applied to the 'hot' gas problem by replacing the chimney by one at a height greater by a length proportional to u^{-n}, where u is the wind speed. Dr. Best shows that the other two formulæ are equivalent to treating the problem in the same way but with additional heights, for (*b*) proportional to u^{-1} (approximately) and for (*c*) to u^{-1}. He calculates the maximum values of concentration of gas at ground-level for various realistic values of wind speed, height and diameter of chimney, and rate of heat output by the chimney relative to the surrounding air, for example, speed of efflux 5 and 15 m./sec., diameter 5 and 10 m., heights 50, 100 and 200 m., and heat output 10^5–10^6 cal./sec.

Formulæ (*a*) and (*b*) give values with ratios mostly nearly unity and with a maximum of 1·66, and formulæ (*b*) and (*c*) give ratios twenty-five of which were less than 2, thirty-eight less than 3, and with the greatest ratios 4·3, 5·6 and 6·4 occurring only for the somewhat abnormally great stack height of 200 m. The results apply only to occasions of a small fall of temperature with height. An inversion above the chimney would make the concentration at ground-level markedly greater. Formula (*c*), which is

$$\text{maximum concentration (mgm./m.}^3) = \frac{9 \times 10^4\, Q}{h(14\,vd + H)},$$

where Q is strength of source in lb./sec., h height of stack (ft.), v speed of efflux (ft./sec.), d diameter of stack (ft.), and H rate of heat output relative to the surrounding air (B.Th.U.), gave the greatest values for the worst conditions of low height, small speed of efflux and low heat output. For this reason, and also because it is the simplest to use, Dr. Best suggests the Oak Ridge formula is the most suitable one for the stack designer.

[1] Sutton, O. G., "Micrometeorology", p. 292 (London, New York and Toronto: McGraw-Hill, 1953).
[2] Best, A. C., *Met. Mag.*, **84**, 297 (1955).
[3] Bosanquet, C. H., Carey, W. F., and Halton, E. M., *Proc. Inst. Mech. Eng.*, **162**, 355 (1950).
[4] Rep. U.S. Atomic Energy Comm., Oak Ridge, Tenn., No. *ORO-99* (1953); formula also quoted in Rep. Comm. on Air Pollution (Cmd. 9322), (London: H.M.S.O., 1954).

NEW NATURE RESERVES IN ENGLAND

THE Nature Conservancy has recently established two new nature reserves—Fyfield Down, Wiltshire, and Westleton Heath, Suffolk—and in addition has acquired further land for the existing nature reserve of Yarner Wood, Devon.

Fyfield Down is one of the finest remaining tracts of unreclaimed high chalk downland in England and is probably the richest in sarsen stones, locally known as 'grey wethers', from their resemblance when seen in the distance to a flock of sheep. It is probable that the great 20-ft. sarsen stones in the circle at Avebury (weighing about 60–70 tons) were brought there from Fyfield Down nearly four thousand years ago to form the oldest important structure in Britain and one unique in Europe. Being close to Avebury, the new reserve is within one of the principal areas inhabited by prehistoric man, and the Celtic field system is one of the largest in England. There is a tumulus to the south of the fields and two others along the western boundary formed by the Ridge Way, which at this point crosses another ancient track known as the Herepath. There are also remains of an ancient village along the 700 ft. contour, the highest point on the reserve being about 830 ft. The sarsens are large blocks of sandstone apparently derived from a bed of sand which covered the site in Eocene times. Their distribution is considered to be natural, none having been erected as standing stones. They produce an effect of great botanical interest, being accompanied by pockets of acid soils, on which grow acid-loving plants such as sheep's sorrel. This is in contrast to the ordinary lime-loving plants of downland; meadow saxifrage (*Saxifraga granulata*)

is abundant in the reserve. The vegetation indicates an exceptionally high humidity, and bluebells grow in the open. A varied moss flora grows on the stones. The grassland of the reserve will continue to be grazed by sheep (rabbits having been virtually eliminated by myxomatosis), and the gallops will continue to be used for training racehorses. More than sixty breeding species of birds have recently been listed at Fyfield Down, including the wheatear, grasshopper warbler and six species of tits; the hen harrier, buzzard, peregrine, quail, hoopoe, and short-eared and long-eared owls have also been observed. The present Declaration by the Nature Conservancy covers an area of approximately 610 acres, about three miles west of Marlborough, which has been leased to the Conservancy by Mr. G. E. Todd, of Manton House. Permits will be necessary for those who wish to collect specimens of animals or plants, or to visit parts of the reserve away from the footpaths. Applications for such purposes should be addressed to the Regional Officer for the South, Nature Conservancy, Furzebrook Research Station, Wareham, Dorset.

Westleton Heath straddles the road between Westleton and Dunwich. Part of this heath is already included in the Minsmere bird reserve managed by the Royal Society for the Protection of birds, and the Conservancy's acquisition of 117 acres on the eastern side safeguards the remainder up to the boundary of the Forestry Commission's Dunwich Forest, which lies between it and the sea. The heath is well known for its birds, including the stonechat, woodlark, red-backed shrike, stone-curlew, lesser redpoll and nightjar. It also has great importance as one of the few good surviving examples of the characteristic and formerly extensive East Suffolk heathlands, most of which have recently been reclaimed for agriculture or afforestation, or have been absorbed by the needs of defence. The dry sandy and shingly soil is of low fertility and is underlaid by the Westleton Beds, sands and gravel of mid-Glacial (Pleistocene) age laid down under marine conditions. It is clothed largely in heather and is crossed or bounded by roads and footpaths to which the public are asked to keep in order to reduce the fire risk and to avoid disturbing the wild life. Inquiries and applications for permits should be addressed to the Regional Officer for East Anglia, Nature Conservancy, 6 Upper King Street, Norwich, Norfolk.

Yarner Wood, near Bovey Tracey, was bought by the Nature Conservancy and declared a reserve in May 1952. A part of the wood was burnt by incendiary bombs during the air raid on Exeter in 1942, and in this section the fire killed about two-thirds of the standing trees and left others badly damaged. It was followed by a dense growth of heather, bilberry and bracken, and a plan was adopted early last year whereby part of the wood was set aside for scientific investigations into different methods of regenerating woodland, for encouraging colonization by insectivorous birds and for population studies of small mammals by the University of Exeter. Otherwise the reserve is being managed to re-establish woodland of the type which is believed originally to have been there. In order to protect and diversify the reserve, an additional twenty-eight acres adjoining the reserve and the *B.*3344 road from Bovey Tracey to Manaton have been bought by the Conservancy. Included in this addition are an interesting small alder wood and bog containing such plants as the royal fern (*Osmunda regalis*). The acquisition includes Yarrow Lodge, which is being converted to accommodate members of the Conservancy's staff working in the reserve, access to which is by permit only and must be strictly limited in order to avoid interference with the programme of scientific research. Inquiries should be addressed to the Regional Officer for the South-West, Nature Conservancy, Furzebrook Research Station, Wareham, Dorset.

BOOKS IN SHORT SUPPLY

TO the specialist bookseller, the supply and prices of books which are no longer in print is a pressing problem to which there is no easy answer. In an address to the Society for the Bibliography of Natural History, C. Kirke Swann explained how the bookseller has to know the comparative scarcity of books as well as their importance to the student or collector (*J. Soc. Bibliography of Nat. Hist.*, **3**, Pt. 3; January 1956). It is surprising to learn that, of those books which have been published during the past fifty years and are seemingly necessary to the student of natural history, about two-thirds of them are out of print. Demand greatly exceeds supply for such well-known books as Goodrich, "Structure and Development of the Vertebrates"; Fraenkel and Gunn, "Orientation of Animals"; Flower and Lydekker, "Introduction to the Study of Mammals"; Noble, "Biology of Amphibia"; Eltringham, "Histological Methods"; Ellis, "British Snails"; Scott, "Studies in Fossil Botany"; Seward, "Fossil Plants"; Hutchinson, "Families of Flowering Plants"; West and Fritsch, "British Freshwater Algae", and many others.

There are several reasons for this scarcity. Some editions were comparatively small and there have been no reprints; copies have been worn out through use, to say nothing of destruction and damage during two great wars; an increased interest in the subject; and comparative lack of new books to replace many of the older standard works.

The situation could be met by reprinting, but here there are several difficulties. Printing to-day is not cheap, especially if there are illustrations to be considered. Another important factor is the number of copies required. Two hundred copies or so of a number of the books would probably satisfy the demand. Reprinting in such comparatively small numbers is not economic unless the price is correspondingly high. It would often result in the prices of reprints being far higher than the present market price of the originals. Some books are rapidly becoming irreplaceable.

In discussing some of the older books the position is rather different. Editions, compared with modern books, were often very small, and in some cases extremely so, ranging from about four or five hundred copies down to less than a dozen. Another factor is the high prices at which many of the books were published, particularly if the present value of the pound, compared with, say, the year 1830, is borne in mind. Many of these older books have almost disappeared from the market and are only to be found in libraries, from which they are seldom, if ever, likely to emerge. Though quite a large number of these are now only of historical interest, they are eagerly sought after by the collector.

A NEW METHOD OF ANALYSING IONOSPHERIC MOVEMENT RECORDS

By Dr. G. L. ROGERS
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IN 1948, Gabor[1] proposed a system of microscopy by reconstructed wave-fronts which is, in effect, a two-stage image-forming process using Fresnel diffraction[2], with the option of changing wave-length half-way. Hitherto the process has been used in conversions from a short wave-length, for example, electron optical[3] or X-ray[4], up to visible light. There is no reason, however, why the method should not be used to scale down a wave-length, and this allows the optical examination of any radio wave pattern which is generated by Fresnel diffraction[5] from a sufficiently small object in an otherwise coherent main beam. The following phenomena suggest themselves as capable of investigation by this technique:

(1) Occultation of a radio-star by a sample of *F*2 region consisting of relatively small patches in an otherwise clear moving ionospheric sky[6].

(2) Ionospheric movement records when the ionosphere is largely a smooth reflector with small imperfections moving across it.

(3) Records obtained when a sensibly smooth reflector has absorbing or phase-contrast patches moving below it; for example, sporadic *E* below F_1, or meteor trails below *E*.

(4) The need for a small object in an otherwise coherent beam may be removed, by supplying a 'coherent beam' artificially from elsewhere, after the Gabor and Goss[7] 'round the square' interferometer. In the case of radio signals, this is relatively easy, as a signal can be taken from the transmitter's master oscillator, suitably attenuated, and fed into the receiver, where it combines with the downcoming signal in accordance with the well-known 'coherent demodulator' technique[8]. In this case, the signal passed direct from the transmitter may conveniently be two or three times the strength of the maximum reflected signal, so that the phase of the sum-term never departs too far from that of the larger signal. Alternatively, the analogy with the Gabor and Goss interferometer may be made complete by replacing the optical 'quadrature prism' by an analogous radio network consisting of two 'coherent demodulator' receivers, one working directly from the transmitter's master oscillator, the other from this signal after passing through a 90° phase-shifting network[9]. The outputs from *both* receivers must be recorded, and may later be combined optically in a Gabor and Goss interferometer. This later technique removes all restriction on the degree of roughness in the ionosphere which may be investigated.

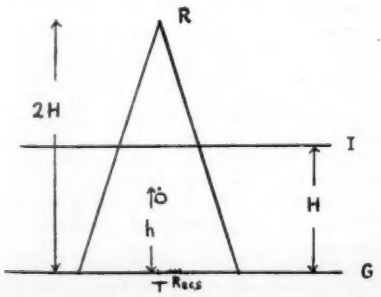

Fig. 1

A preliminary investigation of this technique has now been undertaken. The radio arrangement is shown in Fig. 1. Here we take the ionosphere provisionally as a good reflector, a point we can check later by reconstructing an 'image' of it. The reflexion *R* of the transmitter *T* in the ionosphere, *I*, may be regarded as a point source of coherent radiation diverging from *R*, and giving rise to a diffraction pattern of the object *O*, which will travel over the ground as the projection of *O*'s motion. It is shown elsewhere[2] that this diffraction pattern is characterized by a 'focal length', f_r, given by:

$$f_r = \frac{2Hh}{2H-h} \qquad (1)$$

When the record is converted into a variable-density photographic plate[10], it is found to have a visual focal length, f_v, in a visual wave-length λ_v, given by

$$f_v = \left(\frac{\lambda_r}{\lambda_v}\right)\left(\frac{d}{T.v_g}\right)^2\left(\frac{2Hh}{2H-h}\right) \qquad (2)$$

where λ_r is the radio wave-length, d the distance on the photographic plate corresponding to the time marks on the records, T the time interval between these marks, and v_g the velocity of the diffraction pattern over the ground. The actual velocity of the object, at height h, is

$$v_h = (2H-h)\, v_g/2H$$

To test the method, use was made of existing Dominion Physical Laboratory records, obtained on 2·404 Mc./s. (approximately 125 metres) with a pulse length of about 70 μsec. and a receiver gate of 150 μsec. at 100 pulses per sec. from three aerials arranged according to the Mitra[5] pattern at a spacing of 100 yd. The signals were separated, and each was converted into an equivalent variable-density track[10]. These tracks were then mounted in register and rephotographed, the north aerial track being repeated top and bottom to assist in getting a vertical line. The resultant hologram (Fig. 2*a*), which was just over 1 mm. wide and about 6–8 mm. high in all, was put on to the optical bench and a number of values of f_v were found visually, and confirmed by photography. The photographs show a black line developed in the 'image' of each track: each line is in an ideal case a one-dimensional image of the object *O*. Owing to the time delay in passing over the different aerials, these reconstructed black lines are laterally displaced from track to track, and the corresponding time-interval may be deduced by measuring the shift. v_g may then be deduced at once, using the analysis of Mitra's paper[5]. A particularly good example is shown in Fig. 2*b* and less obvious cases in Figs. 2*c* and *d*. It is believed the latter may be an 'image' of the ionosphere itself, but the evidence is not fully conclusive.

Attempts to deduce v_g are subject to some uncertainty, because of the small scale of the hologram necessary to get a reasonably small f_v. Thus Fig. 2*a* was originally at a scale of about 12μ per sec. A better plate-measuring microscope than available

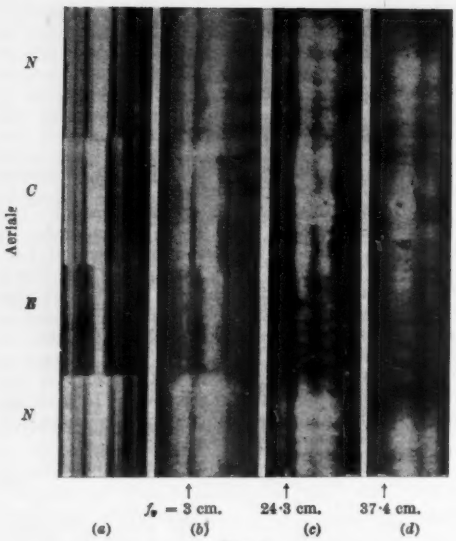

Fig. 2

here might have improved matters, and the use of a longer recorded track would also have assisted, by increasing the resolving power, and reducing the line-width. Case 2*b* is the most accurate; it corresponds to an object moving at 10–15 metres/sec, at a height of 100–300 metres. It is thus abundantly clear that objects far below the ionosphere can make significant contributions to ionospheric movement records.

It will be seen from equation (2) that if v_g is obtainable, everything is known but h; and hence the height of the object may be deduced. Unfortunately, the expression contains a term in v_g^3, and is thus subject to considerable uncertainties. It has, however, an important advantage over traditional methods of analysis in that h is otherwise quite indeterminate.

Fig. 2 also brings out an important point, namely, that most ionospheric movement records are composite, and give information relating to quite different levels. So far as is known, diffraction microscopy constitutes the only method of analysis which gives even partial height discrimination.

In routine use, direct recording of the three signals as variable-density tracks is essential, as the labour of conversion[10] from present variable-area tracks is prohibitive on a large scale. No very great linearity in the recording system is required. Experiments on such direct recording are being considered. On the optical side, methods are being developed to enable the effective visual foci and lateral shifts to be measured rapidly.

For those interested in the mathematics of correlation, it may be noted that 'reconstruction' in a diffraction microscopy apparatus is equivalent to correlating the observed radio diffraction pattern with a wave which is a diametral section through a Newton's ring system, the scale of the latter being varied by moving up or down the optical bench. A sharp peak is expected on the correllogram when the scale of the Newton's ring wave corresponds to one of the visually determined 'image' planes. At the same time, the effects of other phenomena, at different heights, are weakened, and hence the movement velocity obtained by diffraction microscopy is expected to be more reliable than that obtained by other means. The usefulness of this technique will thus be apparent.

I am indebted to the Director of the Dominion Physical Laboratory for permission to use ionospheric movement records obtained by Mr. G. J. Burtt and his staff, also to Prof. G. A. Peddie of this Department for help and encouragement.

[Sept. 26

Note added December 9. Since the above was written, a Dakota aircraft has been sent up on an ionospherically quiet day and a one-dimensional 'image' of it has been recovered by diffraction from one of the aerial records obtained. This confirms a tentative identification of the 100–300 metre object as probably a light aircraft.

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LOCOMOTION OF WORMS

A VERY little naked-eye observation shows that both the usual text-book account of the locomotion of worms (largely based on the work of Friedländer[1]) and the more recent papers by Gray[2] and Gray and Lissmann[3] are inadequate descriptions of how a worm moves.

My interest in the subject was first aroused by the accidental observation, in 1931, that a worm could move on the vertical surface of a sheet of polished tin. I have several times since then seen a worm moving upwards on a vertical surface of glass, such as the side of a beaker. So far as I am aware, no mention of this ability has appeared in the scientific literature, but an account of a worm crawling up a window-pane was given some years ago by an anonymous correspondent in *The Times*[4]. It is clear that such movement cannot be explained by the usual description.

I have observed worms moving on various surfaces, smooth and rough, dry and wet, and in glass and plastic tubes and in other forms of artificial burrows. The species were not determined, but there seems to be no great difference between *Lumbricus* and *Allolobophora*, and as there have certainly been several species and probably other genera among my material, it is probable that locomotion is similar in all the Lumbricidae. The chief points of amplification or correction of the published accounts are the following.

(1) The segments which are moving forwards are often raised a little above the surface; this lifting is increased and unnatural when the worm is on some-

thing such as absorbent paper, which tends to dry it, but may also be seen at other times. From the physical point of view, raising the body must assist locomotion by reducing the resistance to forward motion while increasing that to backward slip.

(2) In spite of (1), there is often much backward slip on a smooth surface, such as glass, and even on quite rough paper. This is especially noticeable when the tail elongates; it then moves backwards, and only in the subsequent contraction of the longitudinal muscles does it move forwards. Slip is also seen (and heard) when the anterior segments shorten and move backwards.

(3) The contraction waves often do not pass more than half-way down the body; if they do not go to the end, the tail is dragged passively forward.

(4) The chætæ are probably of little assistance in locomotion on a surface. So far as I have observed, they are never extruded unless the longitudinal muscles of their segment contract, but it is quite possible for this contraction to occur without extrusion of the chætæ, and if segments remain contracted the chætæ may be gradually withdrawn. In one preparation of the anterior eight segments of a worm, the chætæ several times remained erect after the longitudinal muscles had extended. In extrusion, the chætæ of the anterior part of the body are directed slightly backwards, those of the middle segments are directed radially, with some irregularity, and those of the last twelve or so segments are directed strongly forward. These posterior chætæ are longer than the others. In normal locomotion only the chætæ of the first dozen or so segments are extruded.

(5) Large 'steps' can be taken by the worm on a smooth surface such as glass only if the extreme anterior end is first placed in contact with the surface, and I now have good visual evidence that this end is acting as a sucker. If the worm is observed from below, one can see that the extreme anterior end is pressed against the glass, the peristomium is pressed around it in a ring, and then the central parts of the anterior end are withdrawn from contact with the glass. I have not been able to see any action of the pharynx in this process, as described by Dr. Roots in the following communication, and I think that it is the whole prostomium which is withdrawn. Whatever the exact mechanism, the resulting decrease in pressure anchors the worm, and if the opposing resistance becomes too great, the sucker can be seen to leave the glass with a jerk. If a worm is moving on a stretched 'Cellophane' sheet, it can be seen to suck this inwards as it touches down. This is especially obvious when it is taking big steps. That worms could drag stones and other flat objects by suction was known to Darwin[5], but he did not know that the same method was used by the worm to drag its own body.

(6) When the worm is strongly stimulated at the anterior end, and sometimes when that end is without support, there is backward locomotion of a generally similar type to the normal. The tail end is strongly flattened and the posterior chætæ thrust out; as has been said under (4), these point forwards. It is doubtful if backward locomotion on the surface is ever of much importance in Nature, but it is this reflex which anchors the worm in its burrow and makes it so difficult to pull out. It is not a matter of overcoming a frictional resistance, as described by Chapman[6], but of breaking a system of interlocked structures. Either the soil, or the chætæ, or the worm, must break, and usually it is the last.

(7) I suspect that both the anus and the cut surface of a worm may on occasion act as suckers, but I have no certain evidence that they do.

(8) Fluid sometimes leaks from the dorsal pores, both spontaneously and as a response to prodding. This to some extent discounts the theoretical discussion of Chapman[6].

(9) Movement along a tube is carried out largely by a technique similar to that known to rock-climbers as 'backing up', and it is reasonable to suppose that movement in a burrow or in loose soil is similar. For the initial stages of burrowing, where alone anything can be seen, this has been described by Darwin[5] and Newell[7], and I have confirmed their observations.

(10) When a worm in a tube meets a plug made of soil, it generally tries to get through by the technique just described. If it fails, it extrudes the pharynx to a length of two or three segments and sucks in a mouthful of soil, and continues until a hole is made. Sometimes, presumably when in subjective terms it is hungry, without waiting to try to force its way through, it begins sucking as soon as the prostomium touches the soil, but I have never seen a worm pause to eat soil once its anterior end had emerged beyond the plug. I have once or twice seen the pharynx everted before contact with the soil, but only when the prostomium is very near it. This suggests that the worm is reacting to the sensation of smell. Occasionally a little soil is sucked into the mouth without eversion of the pharynx.

(11) In a tube which is only slightly wider than the maximum diameter of the worm, the animal can completely reverse itself by going through a hairpin curve.

(12) When the worm is in a tube, it has a strong tendency to become quiescent; in this state it does not move, and even strong stimuli induce nothing but contraction of the longitudinal muscles, with no locomotion.

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The absence of an eversible pharynx is given by at least one well-known text-book as a character which distinguishes the Oligochaeta from the Polychaeta; but the eversion of the pharynx can readily be observed in some of the Lumbricidae. It is strange that Darwin, who made extensive observations on earthworms, does not record this fact.

While observing earthworms in soil between vertical glass plates, I noticed that in *Lumbricus terrestris* and *Allolobophora terrestris* forma *longa*, the pharynx is everted during the preliminary testing of the soil before burrowing, and when the worm is eating its way through compact soil. The pharynx is also repeatedly everted on to leaves before they

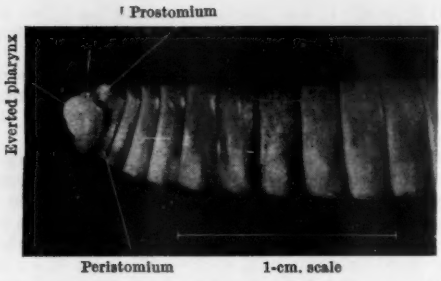

Fig. 1. *Allolobophora terrestris* f. *longa* with pharynx everted

are dragged to the burrow. Darwin[1] records that leaves taken from burrows (and in one case leaves still attached to the plant) are found to have been moistened by an alkaline secretion. It is possible that the secretion may be deposited by the everted pharynx; alternatively, the pharynx may be 'tasting' the leaves. The everted pharynx is shown in Fig. 1, which is a photograph of the anterior end of a specimen of *Allolobophora terrestris* f. *longa* which was fixed while the pharynx was everted.

The pharynx may also function as a sucker, as described by Darwin[2] but without record of its being used for the movement of the worm itself. Anyone who has put some small earthworms into a beaker and left them uncovered knows that after a time they will be found on the bench. Obviously movement up a vertical glass surface cannot be brought about by the mechanism usually described, and the method used is as follows. The anterior end (about nine to twelve segments) is extended upwards, the peristomium and the ventral portion of the prostomium are pressed against the glass, and at the same time the buccal mass and pharynx are pushed forwards and then withdrawn so that suction is developed. Often the pharynx is extruded before contact is made with the glass, so that it is the first to touch the glass. The extended segments then contract, a wave of contraction passes backwards and the body of the worm is dragged upwards. Downward slip is retarded by viscous forces, or in very small worms is prevented altogether by surface tension. Except for the most anterior segments, the ventral surface remains in contact with the glass. I have seen this method of movement in *Allolobophora caliginosa*, *Dendrobaena subrubicunda*, *Eisenia foetida* and *Lumbricus rubellus*.

I have not seen the prostomium used in the way described by Mr. Yapp in the preceding communication, but as the morphology of the anterior end varies from species to species, the method used may also vary in detail while the principle of suction remains the same.

Observations of worms in narrow vivaria have also confirmed that the method described for the initial stages of burrowing[3] (alternate attenuation and expansion of the anterior end) is also used during movement within the burrow and through loose soil.

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PHYTOPLANKTON AND HYDROGRAPHY OF THE PACIFIC PART OF THE ANTARCTIC OCEAN

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THE Norwegian South-Sea Expedition (the *Brategg* Expedition), visiting the Pacific section of the Antarctic Ocean in the summer season 1947–48, collected quantitative phytoplankton samples from seven to eight depths at about sixty stations. From the upper 50 m. net samples were also taken. The samples from the stations along the 120th West meridian have been worked up: stations 33–44, between lat. 57° 22′ and 68° 13′ S., taken January 26–31; station 17, lat. 62° 02′ S., taken December 30. The quantitative samples were analysed by the sedimentation method.

At these stations the hydrographic data demonstrate a marked difference in the upper 200 m. between the sub-Antarctic and the Antarctic zones. The surface layers were in both zones about 50 m. deep; in the sub-Antarctic zone the temperature was 3°–5° C., increasing from south to north, the salinity was 34·0 per mille, σ_t was 26·9–27·1; in the Antarctic zone the temperature was between −1° and +1°C., the salinity 33·4 per mille and σ_t was 26·8–26·9. Below the sub-Antarctic surface layer, the Antarctic intermediate water was characterized by having a temperature minimum located somewhat deeper than the water masses sampled for phytoplankton. Below the Antarctic surface layer the winter-water was found to be colder, saltier and heavier than the upper layer (temperature −1° to −2° C., salinity 34·0 per mille and σ_t 27·4). This winter-water was found between 50 m. and 100 m. The Antarctic Convergence was in December located at about lat. 62° S., and in January at about lat. 61° S. This shift influenced the hydrographical conditions at the two stations worked at the same position: thus station 17 in December belonged to the sub-Antarctic zone, whereas station 38 in January lay in the Antarctic zone.

These hydrographic features are reflected in the distribution of the phytoplankton. The Antarctic zone was far richer than the sub-Antarctic in the total number of cells per litre at each station, and especially so for the diatoms. As a rule, a station in the Antarctic zone had about ten times as many cells as a station in the sub-Antarctic zone. Within the two zones the fluctuations were very small and the increase from the sub-Antarctic to the Antarctic zone at the Antarctic Convergence was most conspicuous (see stations 37 and 38 in Fig. 1).

The vertical distribution differed in the two zones (Fig. 1). In the sub-Antarctic zone, with its com-

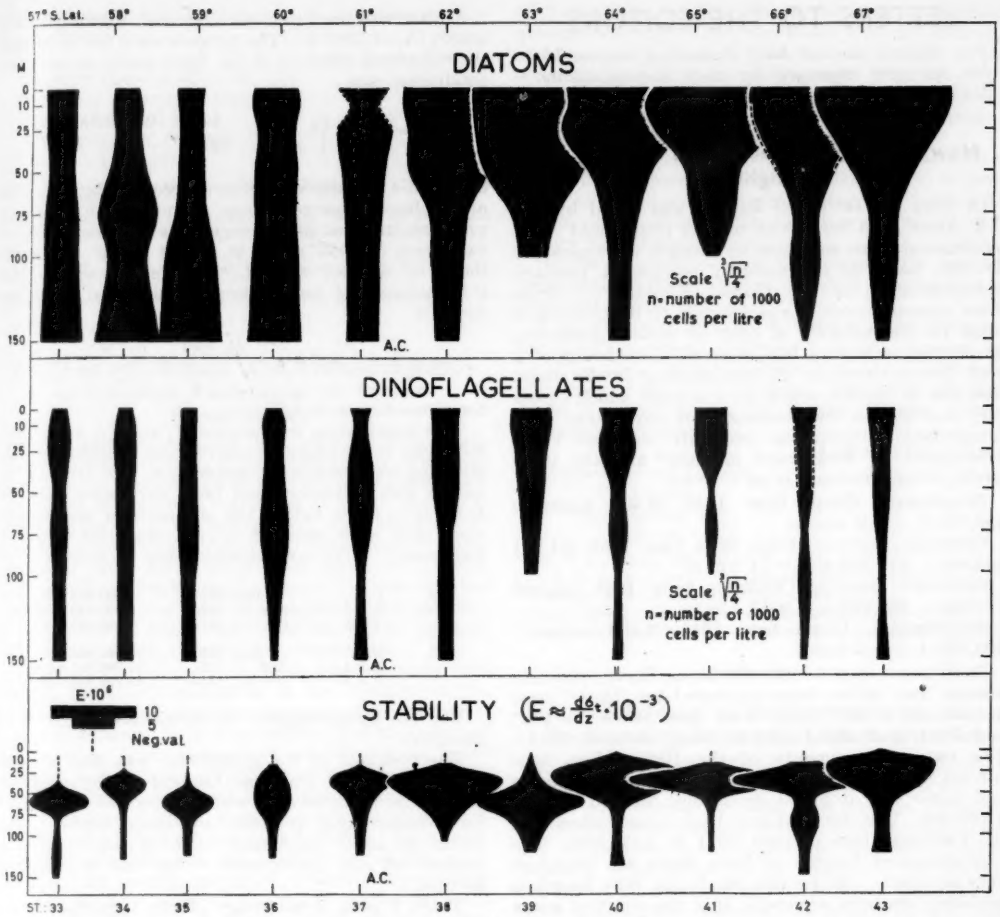

Fig. 1. Vertical distribution of the phytoplankton. AC, Antarctic Convergence. Depths (ordinates) are plotted against positions and stations

paratively low stability, the distribution with depth was approximately even, although at some stations populations were larger at 100 m. and 150 m. than at 0 m., mainly due to the abundance at the lower levels of resting spores of the diatom *Chaetoceros neglectus*. In the Antarctic zone, with its pronounced stability, the large phytoplankton populations were confined to a surface layer of 25–50 m.

In some of the species the Antarctic Convergence acts as a boundary in their horizontal distribution. This is exemplified by the following species.

Coccolithus huxleyi (Lohmann) Kamptner, the only coccolithophorid recorded from the Antarctic ocean, occurred only in the sub-Antarctic zone, at stations close to the Antarctic Convergence.

Thalassionema nitzschioides Grunow is an example of a diatom from the sub-Antarctic zone the numbers of which decreased from December to January. The prevalence in the deeper layer in January also indicates that the vegetation period of this diatom was then at its close.

Nitzschia closterioides n. sp. is an example of a diatom from the Antarctic zone which was not entirely restricted to this zone. The populations in the sub-Antarctic zone were, however, rather small compared with the Antarctic zone, even at the beginning of the season (station 17).

Peridinium applanatum Mangin, the only dinoflagellate recorded in relatively great numbers, was strictly confined to the Antarctic zone.

Chaetoceros neglectus Karsten cannot be characterized as belonging to either the Antarctic or the sub-Antarctic zone. In January no cells were recorded from the sub-Antarctic zone, whereas in the Antarctic zone the populations were rather large. In December, however, the cell numbers in the sub-Antarctic zone were as large as in the Antarctic zone a month later. The increase seems to have started to the north in the sub-Antarctic zone at the beginning of the season, and in January the maximum occurred in the middle of the Antarctic zone, at station 41. This impression of a north to south sequence in the increase of the population is also corroborated by the occurrence of resting spores in the deeper layer of the sub-Antarctic zone in January, and by the fact that numbers of this species showed a sudden increase, not at the Antarctic Convergence, but to the south of this region.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

New Determinations of the Velocity of Light

In 1953 the Ordnance Survey was asked by the U.S. Army Map Service to test its Bergstrand *AGA* geodimeter. This was done by using it to re-measure the two bases of the recently completed primary re-triangulation of the United Kingdom[1]. From these measurements it was possible to deduce a new value for the velocity of light *in vacuo*. Recently, the Ordnance Survey has received the account of a fresh determination by R. Schöldström[2] on the Öland base line in Sweden which gives a value which agrees very closely with that deduced from our results. The comparison between the generally accepted value determined by Bergstrand in 1950[3] and the three recent determinations is as follows:

Bergstrand, Öland base 1950 (5,402 metres): 299,793·1 ± 0·2 km./s.

Ordnance Survey, Ridge Way base 1953 (11,261 metres): 299,792·4 ± 0·11 km./s.

Ordnance Survey, Caithness base 1953 (24,829 metres): 299,792·2 ± 0·13 km./s.

Schöldström, Öland base 1955 (5,402 metres): 299,792·4 ± 0·4 km./s.

Both bases used for the Ordnance Survey determination had earlier been measured by 'Invar' tape in catenary: the Ridge Way base twice, in 1937 and 1951, and the Caithness base once in 1952[4]. The two measurements of the Ridge Way base carried out at different times, using different tapes and under very different conditions, differed by 1 in 1,700,000. The forward and back measurements of the Caithness base differed by 1 in 1,270,000. The tape-measured lengths of both bases are therefore very accurate. Of the two the Ridge Way length is probably the more accurate. It is the weighted mean of two independent measurements, and the base was sited more favourably than at Caithness, where part of the line traversed difficult boggy ground.

The Ridge Way base in Wiltshire runs from White Horse Hill (altitude 858·1 ft.) to Liddington Castle (altitude 914·7 ft.) and for the greater part of this distance the light path is 150–250 ft. clear of the ground. The Caithness base runs from Warth Hill (altitude 408·7 ft.) to Spital Hill (altitude 581·6 ft.) and the height of the light path above ground varies from 0 to about 500 ft. Temperature, barometric pressure and relative humidity were observed at the terminals and the means of the two terminal values used to correct each geodimeter observation. The observations were carried out in variable weather over a number of nights at each base.

A filter was used passing light with a group wavelength (Λ) of 5580 A. The formula used for obtaining the refractive index μ_G of the wave group in ambient conditions was:

$$\mu_G = 1 + \frac{\mu_g - 1}{1 + \alpha t} \times \frac{p}{760} - \frac{0{\cdot}000000055e}{1 + \alpha t}$$

in which t is temperature in degrees centigrade, p is atmospheric pressure in mm. of mercury, e is vapour pressure in mm. of mercury, α is the coefficient of expansion (0·00367), and μ_g is the group refractive index of dry air at 0° C., 760 mm. pressure and 0·03 per cent of carbon dioxide calculated using the formula

$$\mu = 1 + \left(2{,}876{\cdot}4 + \frac{16{\cdot}288}{\Lambda^2} + \frac{0{\cdot}136}{\Lambda^4}\right) 10^{-7}$$

for monochromatic light[5].

Two modulating frequencies (f_1 and f_2) were used, the mean of the observations on both frequencies constituting one complete measurement. The frequencies of the two oscillators had been determined by the U.S. authorities before the dispatch of the instrument and were checked by the National Physical Laboratory. The comparisons were as follows:

f_1	U.S.	June 1953	9,999,944 c./s.
	N.P.L.	Aug. 7, 1953	9,999,932 c./s.
	N.P.L.	Oct. 12, 1953	9,999,945 c./s.
f_2	U.S.	June 1953	10,099,854 c./s.
	N.P.L.	Aug. 7, 1953	10,099,855 c./s.
	N.P.L.	Oct. 12, 1953	10,099,853 c./s.

For the computations the American figures were accepted.

The constant of the geodimeter was also verified at the National Physical Laboratory by a direct method using the 50-m. mural base normally employed for standardizing geodetic surveying tapes. The value obtained confirmed that obtained by the makers of the geodimeter, who use a different method.

Table 1 gives a summary of the important data relating to the determinations of the velocity of light by means of the geodimeter at the two bases in the United Kingdom. The rejected observations were those taken under unfavourable conditions (for example, unpractised observer, very still air).

Because of the probable greater accuracy of the Ridge Way base-length and the greater variation in height of the Caithness light-path, the Ridge Way value, 299,792·4 km./sec., is the more reliable.

It is clear from Schöldström's account that his determination is also a very strong one. In arriving at his error limits, he has taken into account the uncertainty due to errors in his accepted values for temperature, pressure, humidity, colour and frequency. The limits given for the Ordnance Survey values are simply the mean square errors deduced

Table 1

Period 1953	Line: geodimeter station first	Length from base measurement (air distance)	No. of obs.	Root mean square errors		Remarks
				Single observation	Mean	
July 5–29	White Horse Hill Liddington Castle	11,260·677 ± 0·003 m.	14	0·010 m.	0·003 m.	3 observations rejected
Aug. 13–24 Sept. 20 to Oct. 5	Warth Hill Spital Hill	24,828·626 ± 0·010 m.	16	0·030 m.	0·007 m.	Of the 23 observations, 7 were rejected, 3 from the first visit and the remainder from the second

from internal evidence and are not therefore strictly comparable.

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Electron Microscopy and Radioautography as Coupled Techniques in Tracer Experiments

Considerable progress has already been made towards high resolution in radioautography, and good results have been obtained by various workers with the Ilford peeling film technique of Pelc[1], the *NTB* stripping method of Boyd[2] and the 'wet-process' system of Gomberg[3]. Lately, I have shown[4] that, by using thick layers of nuclear emulsions (300μ), and avoiding background effects by placing the specimens in a coal mine at a depth of 600 metres[5], it is possible to follow the β-particle tracks to their origin and obtain a one-micron resolution.

Films of the sensitive emulsion may be made thin enough to allow observation in the electron microscope, thus adding greatly to the resolution. The process is as follows. Microscope slides, specially selected for freedom from radioactive contamination, were covered with a layer of collodion or 'Formvar'. In the experiment described here, the specimens were nuclei extracted from tumour tissues and labelled *in vitro* with cobalt-60 (β-ray, 0·3 MeV.). They were placed on the collodion and covered with a thin layer of Ilford *G5* nuclear emulsion, obtained by melting the gel at 55° C., as in the usual procedure, and diluting it with water to the proper consistency. The slides, after drying, were placed for exposure in a thick-walled lead box. As a proportion only of the β-particles are likely to be emitted in the plane of the sensitive layer, the necessary exposures are longer than in the thick-layer method previously employed.

The slides were developed in Ilford *P.Q.* Universal developer, cleared in hypo within 20 sec. and fixed for 2 min. After washing, the double layer of collodion-gelatine was lifted from the slides without difficulty and mounted in the electron microscope. The accompanying electron micrograph (Fig. 1) shows the tracks emitted by four single nuclei at a magnification of 2,000 (reduced from the original magnification of 6,000).

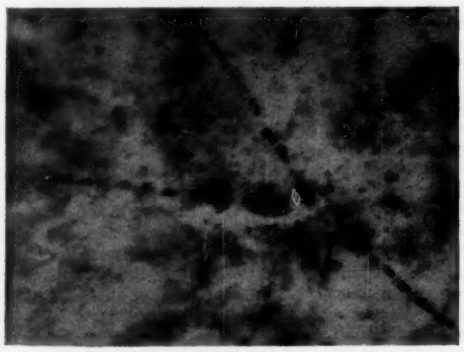

Fig. 1. Electron micrograph of β-ray tracks emitted by tumour nuclei labelled with radioactive cobalt-60. × 2,000

This new technique, successful for the particles of cobalt-60, of energy 0·3 MeV., is likely to be of great value in the case of the soft radiation of carbon-14, as the grains of the tracks are close enough to allow a very high magnification.

So far the method has been applied to isolated cells and cell nuclei, but it is hoped to extend it to ultra-thin tissue sections.

I am indebted to Prof. J. Sayers, of the Electron Physics Department, University of Birmingham, for facilities, and I wish to acknowledge the skilled technical help of Mr. C. C. Newton. This work was done under a grant from the British Empire Cancer Campaign, London.

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Zinc-deficiency of *Hevea brasiliensis* as a Predisposing Factor to *Oidium* Infection

Infection of the *Hevea* rubber tree by *Oidium heveae* is common in Malaya but is not regarded as a major pathological problem; in Ceylon, however, the fungus can produce serious loss of crop yields and the problem is of economic importance[1]. *Oidium heveae* is most prominent in Malaya at the time of refoliation after 'wintering' of the trees, when it may cause a secondary leaf-fall. It is only at this time that *Oidium* is found on leaves exposed to full sun. Throughout the year it may be found on young plants but only when these are shaded, and then never sufficiently seriously to cause defoliation. A small number of poorly developed colonies of *Oidium heveae* are usual on the leaves of plants grown in our plant-house[2] as the glass and framework of the house provide light shade. During the study of the micro-nutrient-deficiency symptoms of *Hevea brasiliensis* grown in sand culture within this house, a striking relationship between the susceptibility to severe *Oidium heveae* attack and the zinc status of the plants was noticed. This relationship was not noted for the copper- or molybdenum-deficient plants grown simultaneously and in the same environmental conditions as the zinc-deficient plants. Our observations were thus made on plants grown under glass and were derived from one experiment only; the results, however, were so well marked that their significance should be quickly tested and evaluated in countries where *Oidium heveae* attack is of major concern.

'Selfed' seeds of clone Tjirandji 1 were sown in sand which had been rigorously purified by boiling with hydrochloric – oxalic acid mixture, and which was contained in 'Pyrex' glass vessels. Two types of nutrient, all nitrate nitrogen or part nitrate- part ammonium-nitrogen, were supplied to the seedlings;

but as this did not influence the main result described below, it will not be mentioned further. The nutrients were freed from zinc by subjecting them to phosphate adsorption followed by dithizone extraction, essentially as described by Hewitt[3], whose procedure was also employed for the purification of the ferric citrate. Zinc was supplied in the 'complete' nutrient solution at a concentration of 0·065 part per million; this was the only factor wherein the 'complete' cultures differed from the zinc-deficient cultures. Water which had been purified by passing through ion-exchange resins was used throughout.

Three months after sowing, severe symptoms of zinc deficiency occurred; these included rosetting, production of narrow, strap-like, young leaves with wavy margins, chlorosis and malformation of young laminæ, death of growing points, production of numerous lateral shoots and severe stunting (Fig. 1). That these symptoms were truly those of zinc deficiency was proved by the recovery of the affected plants when supplied with 'complete' nutrient. Plants which had received the 'complete' nutrient solution throughout the experiment grew rapidly and well and remained comparatively free from disease; but from the sixth month onward, the zinc-deficient plants became severely infected with *Oidium heveae*. The heavy infection was confined to those parts of the plant formed in the absence of a sufficiency of zinc.

Abnormally large and heavily sporing colonies of *Oidium heveae* were found on the laminæ (Fig. 2); the fungus also completely enveloped the growing tip of the severely deficient plants and some of the newly formed leaves fell. The 'complete' nutrient plants, grown adjacent to the zinc-deficient plants, showed only the odd, feebly developed colony usual on all plants in the plant house.

An analysis of plants sampled six and a half months after sowing showed that the 'complete' nutrient plants contained eight to ten times as much zinc per plant as the zinc-deficient ones.

Fig. 1. Complete nutrient plant (left); zinc-deficient plants (right). One scale division equivalent to three inches. Eleven-month old seedlings

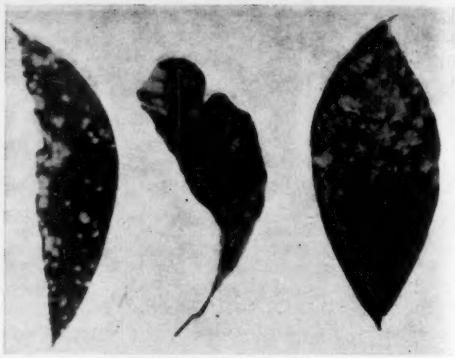

Fig. 2. Zinc-deficient laminæ heavily infected with *Oidium heveae*. Top surface, two laminæ on left; bottom surface, lamina on right. ⅔ nat. size

It seems likely that without a sufficiency of zinc the rubber plant is unable to produce enough of a certain metabolite which confers some degree of resistance to *Oidium heveae* attack. We plan to repeat our experiment in order to determine whether substances other than zinc can confer resistance. In the meantime, it appears possible that in some areas the prevalence of *Oidium heveae* may be accounted for by a lack of zinc available to the plants.

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Reduction–Oxidation Level of Soils

Several attempts have been made to determine the redox potentials of soils by inserting a suitably treated platinum electrode into the soil suspension and measuring the e.m.f. against a reference electrode; but from a strictly physico-chemical point of view one cannot speak about well-established redox potentials in soils, which are derived from experimental data. To avoid these difficulties, the use of the empirical term 'redox level' is suggested, thereby giving an expression for the mean reducing or oxidizing activities in dry soil samples.

If a soil is treated with a solution containing the reversible redox system potassium ferrocyanide and ferricyanide, the e.m.f. of a platinum electrode measured against a reference (calomel) electrode in the soil suspension will be different from the potential in the pure solution. These differences, ΔE mV., may be correlated with the reducing or oxidizing properties of the soil. By treating the same soil with solutions containing potassium ferro- and ferricyanides in different ratios, all buffered with 1 M ammonium acetate, and plotting ΔE found against the E values of the pure solutions, one gets an S-shaped curve, which intersects the E-axis in the point E'. This point corresponds to a solution that does not change its redox potential in contact with

Table 1

Soil	E' (mV.)	Total Mn (p.p.m.)	pH in 1 N KCl quinhydrone	pH′
1	389	45	5·1	5·08
2	486	123	4·8	4·06
3	456	152	5·0	4·73
4	483	165	6·8	6·82
5	508	328	4·3	3·70
6	511	395	5·3	5·32
7	566	695	5·5	5·53

the soil; thus it may be regarded as an expression for the redox level of the soil.

In seven totally different Danish soils the following measurements have been carried out: 10 gm. air-dried soil was shaken for 1 hr. at room temperature with 50 ml. of ferrous-ferric-cyanide solutions, all buffered with 1 M ammonium acetate. The concentration of potassium ferro- and ferri-cyanide varied between 10^{-4} and 10^{-2} mole/l., and the E values measured were all referred to the normal hydrogen electrode. Total manganese was determined by ignition of the soil and subsequent treatment with hot hydrogen peroxide solution containing nitric acid. Manganese was determined colorimetrically as potassium permanganate in the filtrate. Table 1 and Fig. 1 show a linear correlation between the total manganese content and the values of E', indicating that with increasing content of total manganese the redox level increases proportionally.

The values of ΔE were quite reproducible, but they could be caused by either absorption or precipitation of the iron-cyanide ions in the soil suspensions instead of merely by redox processes as indicated by:

$$Fe(CN)_6^{----} \rightleftarrows Fe(CN)_6^{---} + e^-.$$

In the strongly buffered solution containing acetate and iron cyanide ions in a ratio of at least 100 : 1, extensive absorption of the iron cyanide ions is not likely to occur. Several heavy metals might precipitate the iron cyanide ions, but in the presence of, for example, 3·75 p.p.m. zinc, the maximum precipitation cannot exceed 0·1 per cent of the total in the case of ferrocyanide, which would cause an increase of 3 mV. in the e.m.f. measured. This difference is only about of the same order of magnitude as the experimental error. For soils rich in iron, one would expect precipitation of ferro- and ferri-cyanide compounds, but tests have shown that in the strong acetate medium iron ions are blocked as acetate complexes.

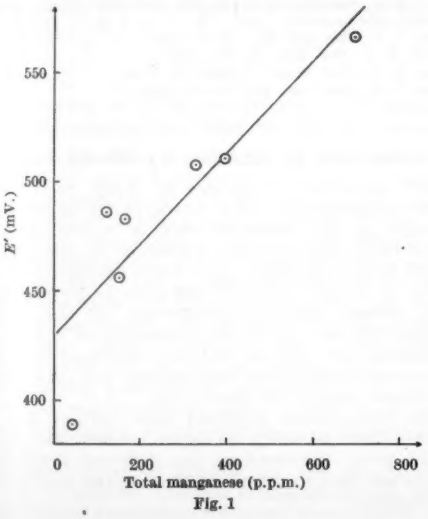

Fig. 1

A soil very rich in iron oxides was found to give $\Delta E = 0$ for a ratio of ferri- to ferro-cyanide of 13·8. This soil was shaken with solutions containing iron cyanides in this ratio, the total concentration of which was varied by ten-fold dilution, while the ammonium acetate concentration was kept constant at 1 M. This experiment showed that ΔE still remained close to zero, that is, E' is independent of the dilution.

The same principle has been used in connexion with pH measurements in soils. 10-gm. portions of the seven soils were shaken with 100 ml. of 1 M potassium chloride solutions buffered with citric acid and disodium hydrogen phosphate in a total concentration of about 0·01 mole/l. These solutions had a pH ranging from 2·8 to 7·3. After 1 hr., the pH of the suspensions was determined by glass-electrode measurements, and the differences (ΔpH) between the pH of the suspensions and those of the pure buffer solutions were plotted against the pH of the buffer solutions. Here again an S-shaped curve was formed, and the intersection with the pH-axis at the point pH′ indicated a buffer solution of such a composition that it did not change its pH by contact with the soil. Therefore pH′ is identified as the pH of the soil, here measured with quinhydrone in 1 N potassium chloride soil suspension, and as shown in Table 1 this is true for four of the seven soils having a pH greater than 5. The discrepancies are probably due to complex formation with trivalent metals, for example, ferric or aluminium ions.

By these methods it might be possible to study the concept of redox capacity as well as buffer capacity, and they enable the study of problems such as the ageing of the soil during storage or changes in exchangeable manganese during transfer of the soil from natural conditions to the laboratory. Investigations are being continued and a more detailed publication will appear.

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Occurrence and Nature of an Amœba Excystment Factor produced by *Aerobacter* sp.

Although an excystment factor potentiating the emergence of trophozoites from their resting cysts in Protozoa has long been postulated, there has so far been no convincing experimental evidence of its existence. A critical appraisal of previous work[1-4] has revealed that the factor has variously been attributed to hypo- and hyper-tonicity of the medium, low oxygen tension, change of pH, reducing agents, presence of enriched nutrient media, change of temperature, etc. Earlier workers in this field do not appear to have adequately recognized the risk of extraneous infection inherent to such experiments, particularly when nutritionally rich and highly susceptible media, such as 'Difco' yeast extract, are examined for the presence of this factor[5]. Unless absolutely aseptic conditions are maintained in the course of experiments, the results will remain open to doubt.

Crump[1] showed that excystment in *Amœba* Z (*Didascalus thorntoni*; Singh[6]) took place without the presence of bacteria, while *Amœba* 4 (*Schizopyrenus russelli*; Singh[6]) excysted only in the presence of certain bacteria (*Aerobacter* sp. and 4036). She suggested that the two species of bacteria produce in the medium some material that induces excystment in *S. russelli*. In view of Crump's[1] findings, it was of interest to secure an experimental proof of its occurrence and elucidate the nature of the factor produced by *Aerobacter* sp., Strain 1912; Singh[7]. As bacteria and amœbæ live in close association in human and animal intestines, a detailed study of amœba excystment factor or factors, produced by *Aerobacter* and other intestinal bacteria, would be of considerable significance for a more effective approach to the problem of amœbic dysentery.

Large numbers of mature cysts of *S. russelli* (see Singh[6] for culture methods) produced on *Aerobacter* sp. on non-nutrient agar (2·5 per cent agar, 0·5 per cent sodium chloride; *p*H 6·8–7·0) were treated with a mixture of penicillin (4 units/c.c.) and streptomycin (4 μgm./c.c.) solution for about 24 hr. at room temperature (25°–26° C.). They were washed by centrifugation with 0·85 per cent sodium chloride and tested for their sterility on nutrient agar slopes and for viability by inoculating them in the presence of *Aerobacter* sp. on non-nutrient agar. The sterilized cysts, thus treated, excysted readily in the presence of living bacteria, although on non-nutrient agar alone there was scarcely any excystment. These cysts have been used in all the subsequent experiments.

Aerobacter sp. five days old grown in nutrient broth at 37° C. was washed twice on the centrifuge with ice-cold saline, in which it was finally dispersed as a uniform suspension. Aliquots of the suspension, heated at 100° C. in a vigorously boiling water-bath for different periods, were tested for their capacity to induce the excystment of sterilized cysts. The bacteria were spread on non-nutrient agar plates and inoculated with large numbers of cysts. In the presence of even the 5-min. heat-treated bacteria, on rare occasions, only a few active amœbæ could be seen after 24–48 hr. incubation at 25° C., but they did not multiply. After three days, when washed resting cells of *Aerobacter* sp., preserved at 5° C. for 72 hr., were added, the great majority of the cysts excysted within 24 hr., showing that the excystment factor produced by *Aerobacter* sp. is highly thermolabile.

When placed on non-nutrient agar with *p*H adjusted at different levels (2·2, 3·0, 4·0, 5·0, 6·0, 7·0 and 8·0), the cysts did not show any sign of excystment, even after a period of 48–72 hr.; but when *Aerobacter* sp. was provided, excystment occurred generally and was independent of *p*H. Excystment, however, occurred more readily in the *p*H range 5–8.

Addition of reducing substances like cystine, cysteine, glutathione, thioglycollic acid and ascorbic acid to the non-nutrient agar did not induce excystment unless *Aerobacter* sp. was added.

Collodion cups (25 mm. diameter and 12 mm. height) were cast from a 6 per cent solution of collodion in ether–ethanol mixture (Merck) and sterilized in distilled water by autoclaving for 15 min. at 15 lb./sq. in. A layer of non-nutrient agar was poured in the sterile cups, which were placed on the surface of a papain-digest meat-agar plate heavily seeded with *Aerobacter* sp. Plenty of cysts were inoculated on the non-nutrient agar surface in the cups and incubated at 25° C. In the control experiments, the nutrient agar was not seeded. The majority of cysts excysted within 24 hr. in experiments in which *Aerobacter* sp. was inoculated in nutrient agar and allowed to multiply actively. After 48–72 hr. the amœbæ either encysted or died due to the lack of food. In control experiments only a few active amœbæ could be seen. This experiment clearly shows that *Aerobacter* sp. produces some substance that passes through a collodion membrane and into non-nutrient agar and causes the excystment of the amœbal cysts.

The experiment was repeated by reversing the relative positions of the seeded nutrient and non-nutrient agars—the seeded nutrient agar being placed in the collodion cup and the cysts on the surface of non-nutrient agar. In yet another series of experiments, the seeded nutrient agar in the cup was replaced by nutrient broth inoculated with *Aerobacter* sp. It was found that the factor was elaborated by *Aerobacter* sp., growing in the nutrient agar or broth as the case may be, and diffused through the collodion membrane into the non-nutrient agar, where its presence was revealed by the ready excystment of the amœbal cysts when placed on it. The factor could not be found in the unseeded controls.

It would appear that an excystment factor is produced by the actively proliferating culture of *Aerobacter* sp., which is capable of diffusing easily and rapidly through a collodion membrane into the agar gel. The factor is thermolabile and does not appear to be related to either *p*H or to any of the reducing substances tried by us, although both these factors may be expected either to condition the cysts to the action of the excystment factor or augment its potency. Work on the isolation and further characterization of the factor is now in progress.

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Utilization of Xanthin by Mould Fungi

The utilization of purines by fungi as the sole source of nitrogen in their nutritive media has been reported in the literature only in a few cases[1–3]. No work concerning the utilization of xanthin by mould fungi appears to have been published.

One of us (E. D. M. T.) has already shown[4] that many fungal species representing all the fungal groups were able to grow luxuriantly in a medium containing uric acid as the only source of nitrogen. It was also possible to demonstrate the presence of the uricase enzyme in those fungi.

The experiments reported here carried out on xanthin have revealed, as Table 1 shows, that many mould fungi representing the different systematic groups are able to utilize xanthin as the only source of nitrogen.

Table 1. Growth of Different Mould Fungi on Czapek–Dox-Xanthin Medium

Fungal group			Growth
Phycomycetes :			
Mucor fragilis			medium
Ascomycetes :			
Aspergillus niger			good
A. fumigatus			medium
Penicillium chrisogenum			medium
Fungi imperfecti :			
Fusarium semitectum,		*U*1	good
,,	,,	*U*4	luxuriant
,,	,,	*U*9	medium
,,	,,	*U*11	luxuriant
,,	,,	*U*12	luxuriant
,,	,,	*U*14	luxuriant
,,	,,	*U*16	luxuriant
,,	*niveum*		medium
,,	*sambucinum*,	*U*7	good
,,	,,		good
,,	*oxysporum*,	*U*6	luxuriant
,,	,,	*U*10	medium
,,	,,	*U*15	good
,,	*moniliforme*,	*U*2	good
,,	,,	*U*13	good
,,	*equiseti*		luxuriant
Alternaria tenuis,		*U*18	good
,,	,,	*U*30	luxuriant
,,	,,	*U*47	luxuriant
,,	,,	*U*48	good
,,	,,		trace—weak
,,	*porri*		weak
Cladosporium cladosporioides			weak

The basic medium utilized was Czapek–Dox. The sodium nitrate of this medium was replaced by nitrogen-equivalent amounts of xanthin. The salts used in preparation of the medium were *A.R.* grade. The cultures were made in 50-c.c. Erlenmeyer flasks each containing 15 c.c. of the sterilized medium; five flasks were made for each individual fungus. All the flasks were inoculated with the same standard inoculum; the inoculated flasks were incubated at 28° C. for eight days, after which the dry weight of the mycelial mats was recorded.

Preliminary enzymatic studies have revealed the presence of xanthin-dehydrogenase enzyme in some of the fungi examined.

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Inhibition of L-Asparaginase in Extracts of *Mycobacterium phlei* by D-Asparagine

The concept that substances related chemically to a metabolite might interfere with the normal function of that metabolite or displace it from the site of attachment to the appropriate enzyme[1] is now well established. Accordingly, an unnatural stereoisomer of a metabolite could also be regarded as a potential antimetabolite; but it was surprising to find that only a few unnatural amino-acids did, in fact, interfere with the growth-promoting effects of their natural antipodes. Thus, D-leucine[2] and D-tryptophan[3] interfere with the growth-promoting effects of the corresponding L-isomers in lactobacilli, and D-glutamic acid was found partially to inhibit the activity of the L-glutamic acid decarboxylase obtained from *E. coli*[4].

In the course of studies on the asparaginase activity in cell-free extracts of *Mycobacterium phlei*, we found that L-asparagine, but not the D-isomer, was attacked by this enzyme. Moreover, D-asparagine was found to inhibit the enzymatic deamidation of the L-isomer.

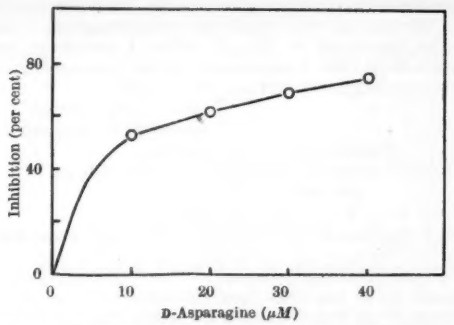

Fig. 1. Inhibition of L-asparaginase activity by increasing concentrations of D-asparagine. Total volume: 1 ml., containing L-asparagine, 10 μM; D-asparagine, varying from 0 to 40 μM (Nutritional Biochemical Corp., U.S.A.). Bacterial extract, 2·5 mgm. protein; phosphate buffer *p*H 8·2, *M*/150. Incubation, 90 min. at 37° C.

The organism (*M. phlei* 271 from the culture collection of this Department) was grown in Roux bottles on nutrient agar supplemented with 0·1 per cent 'Tween-80' (polyoxyethylene sorbitan monooleate, Atlas Powder Co., U.S.A.). After incubation at 35° C., for three to four days, the bacteria were washed three times with distilled water, centrifuged and concentrated to about 2–3 gm./20 ml. of wet weight.

The thick suspension was disintegrated by a Raytheon 9*KC* sonic vibrator for 25 min. The supernatant, from which the debris was removed by high-speed centrifugation (at about 20,000 *g* for 20 min.), was dialysed against running water for 13–15 hr. The whole procedure was carried out in the cold room. The protein content of the dialysate was determined by Mehl's biuret method[5]. The asparaginase activity of the extract was estimated from the ammonia formed (by the Conway microdiffusion method) and from the amount of aspartic acid produced (by quantitative paper chromatography, after Giri *et al.*[6]).

Fig. 1 shows the effect of increasing amounts of D-asparagine on the inhibition of the L-asparaginase activity; at an inhibitor/substrate ratio of 4 : 1, an inhibition of 75 per cent was obtained. In order to establish the nature of the inhibition the reaction

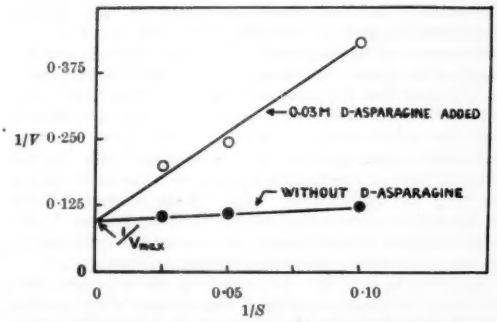

Fig. 2. Effect of substrate concentration on inhibition of asparaginase activity by D-asparagine. The same arrangement as in Fig. 1, except for concentrations of substrate and inhibitor. L-asparagine concentrations were 10, 20 and 40 μM respectively; D-asparagine, 0 and 30 μM respectively. *V*, reaction velocity, μmole of ammonia produced in 90 min. *S*, substrate concentration in μM

velocity was measured at various concentrations of the substrate (L-asparagine) in the presence and in the absence of the inhibitor (D-asparagine). The results presented in Fig. 2 (after Lineweaver and Burk[7]) show that D-asparagine inhibits competitively the L-asparaginase activity of *M. phlei*.

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Effect of Sialoadenectomy on Thyroid Activity

The rapid appearance of iodide in saliva following administration of iodide iodine-131 has been demonstrated[1], and its measurement has proved useful in the evaluation of the thyroid status of clinical cases[2]. Recently, an experiment has been reported[3] which suggested that the salivary glands may play an important part in thyroid metabolism, involving the removal of iodine-131 diiodotyrosine from the peripheral circulation. Dehalogenation processes by characteristic enzymes in the salivary gland tissue have been observed[4].

Our present preliminary observations indicate that the salivary glands play an important part in regulating the activity of the thyroids of the mouse and the rat. We employed adult male mice (N.I.H.) weighing 25 ± 1 gm. throughout. Animals were housed in conventional cages in a room the temperature of which was maintained at 25 ± 3° C. The daily ration consisted of commercial mixed grains and water, *ad libitum*. Submaxillary, parotid and sublingual glands were removed under aseptic conditions seven to ten days prior to measurements of thyroid activity. Sham-operated controls were employed throughout. In each experiment sham controls and sialoadenectomized animals were given equal periods of post-surgical rest. Carrier-free iodine-131 as iodide and carrier-free phosphorus-32 as phosphate were administered intraperitoneally in the doses indicated in the tables. Experimental groups contained at least ten and not more than twelve animals. Thyroids were removed, weighed on a microbalance to the nearest 0·01 mgm., and plated for radiological assay as described previously[5]. Radio assays of iodine-131 were performed with the aid of an end-window Geiger–Müller counter and scaler; phosphorus-32 was assayed with the aid of a scintillation counter sensitive to β-particles and a Dumont photomultiplier tube. Assays were pre-set for count to give a statistical error less than 1 per cent. Results are expressed as counts per min./mgm. tissue or as a percentage of control-animal values.

The results in Table 1 shows that sialoadenectomy, performed on mice, increased the uptake of iodine-131 by the thyroid in the first four hours following administration of radioactive iodide. The iodine-131 content of the mouse thyroids, measured 24 hr. later, indicates a delayed turnover of iodine-131 in the sialoadenectomized animals as compared to that in the control groups. Repeated experiments substantiate the initial observations. Sialoadenectomy also produced similar changes in the rate of iodine-131 metabolism in the thyroids of rats. 24-hr. thyroid iodine-131 levels are always less than those found in sham-operated control rats (Table 2).

Table 1. Effect of Sialoadenectomy on Uptake of Iodine-131 by Mouse Thyroid following Injection of 5 μc. Iodine-131 per 25 gm. Body-weight

Group	Average 4-hr. uptake (counts per min./mgm.)	(Per cent)	Average 24-hr. uptake (counts per min./mgm.)	(Per cent)
Sham controls	1,350 ± 147*	100	4,958 ± 133*	100
Sialoadenectomized	1,736 ± 234	129	1,932 ± 373	39

* Standard error of the mean.

Table 2. Effect of Sialoadenectomy on Thyroid Activity of Rats 24-hr. uptake, 20 μc. iodine-131 per 100 gm. body-weight

Group	Average counts per min./mgm.	Per cent
Controls	824 ± 33*	100
Experimental	555 ± 54	67·3

* Standard error of the mean.

To test the probable changes of the levels of thyroid-stimulating hormone in animals deprived of their salivary glands, resort was made of the titre of the hormone indicated by phosphorus-32 uptake by the thyroid glands[6]. The results indicated in Table 3 are the preliminary observations following uptake of phosphorus-32 for 1 hr. by mouse thyroids in control and sialoadenectomized animals. Administration (intraperitoneal) of 5 μgm. of the hormone restored the phosphorus-32 activity of the thyroids of desalivated mice to normal levels (Table 3).

Table 3. Titre of Thyroid-stimulating Hormone and Effect of Injected Hormone measured by Phosphorus-32. Uptake of Phosphorus-32 by Mouse Thyroids 1 hr. after Injection of 50 μc. Radioactive Phosphate

Group	Average counts per min./mgm.	Per cent
Controls	366 ± 25	100
Sialoadenectomized	227 ± 29	62
Controls + 5 μgm. hormone 1 hr. prior to phosphorus-32	433 ± 63	118
Sialoadenectomized + 5 μgm. hormone 1 hr. prior to phosphorus-32	416 ± 160	114

The observations recorded here indicate that the salivary glands play an important part in the regulation of the activity of the thyroid gland, probably via control of the production and/or the utilization of thyroid-stimulating hormone. The influence on the titre of the hormone is apparent since the desalivated mice in these studies showed uptakes of phosphorus-32 by the thyroid that were consistently lower (30–38 per cent) than that observed in intact control animals. Further, the phosphorus-32 uptake-response of sialoadenectomized mice to a single 5-μgm. dose of thyroid-stimulating hormone showed a gain of 84 per cent above their base values, whereas control animals exhibited a gain of only 18 per cent above their base values.

The thyroids of sialoadenectomized mice incorporate iodine-131 more rapidly than those of control animals in the 4-hr. test period, but they also appear to utilize thyroid iodine-131 at a subnormal rate as indicated by the iodine-131 content of the thyroids after 24 hr. The initially higher uptake of radioactive iodine in the sialoadenectomized mice may be due to the loss of the normal iodide spillway into the saliva[1] which could lead to higher concentrations in the circulating fluids with consequent increase in iodine-131 trapped by the thyroid. The reduced levels of thyroid iodine-131 and the low titre of thyroid-

stimulating hormone indicated by uptake of phosphorus-32 are not difficult to explain in view of our preliminary studies on the rate of disappearance of thyroid iodine-131. The uptake of iodine-131 in sialoadenectomized mice is maximal at 6–8 hr. and the iodine-131 disappears from the thyroid quite slowly or not at all in the 24–48 hr. interval, indicating reduced titre of thyroid-stimulating hormone.

The increased sensitivity of thyroid-stimulating hormone (Table 3) suggests that some regulating mechanism is impaired when salivary glands are removed from the mouse. Whether the effects produced are due to a hormonal or enzymatic regulator presumably present in salivary glands is not yet known.

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Effect of Vitamin D on the Phosphorus Content of Rachitic Rat Cartilage

Earlier investigations[1] in these Laboratories had indicated that vitamin D influenced carbohydrate metabolism in calcifying cartilage of the albino rat. Since carbohydrate and phosphorus metabolism are closely interlinked, the present investigation was undertaken with the view of determining the influence of vitamin D on the phosphorus content of rachitic rat cartilage.

Healthy albino rats four weeks old were distributed in seven groups; the first six groups contained ten rats in each, while the last one contained twenty animals. All the animals were fed a modified rachitogenic diet[2] for twenty-one days. At the end of this period, animals in group I were killed, their tibial epiphyseal cartilages quickly removed and placed individually in tubes and dried at 90° C. Animals in groups II–VII were fed a single dose of vitamin D (4,000 I.U.). Exactly 24 hr. after vitamin D administration, rats in group II were killed and their tibial cartilages removed and dried. The animals in the remaining groups were killed at intervals of 24 hr. The dried cartilage of each rat was weighed and its total phosphorus content determined colorimetrically after wet ashing. The results are presented in Table 1.

It will be seen that the administration of vitamin D caused a gradual increase in the total phosphorus content of the cartilage. At 96 hr. after vitamin D administration, the phosphorus content of the cartilage was maximum, being about twice that contained in the cartilage of the untreated rachitic animal.

It is not clear at this stage why the phosphorus content of cartilage decreases after 96 hr. It may be mentioned, however, that this fall coincides with

Table 1. Total Phosphorus in Cartilage from Rachitic Rats and Rats given Vitamin D

Group No.	Hr. after vitamin D	No. of observations	μgm. phosphorus/ mgm. dry cartilage
I	0	10	9·78 ± 1·72
II	24	10	11·00 ± 1·15
III	48	10	14·13 ± 1·71
IV	72	10	13·14 ± 1·49
V	96	10	20·94 ± 2·37
VI	120	10	17·21 ± 2·38
VII	144	20	12·21 ± 1·41

(*a*) the maximum increase in calcifying capacity *in vitro* shown by the cartilage of the animals treated with vitamin D, and (*b*) the commencement of calcification *in vivo*, both of which have been demonstrated by Dikshit and Patwardhan[3] to occur at 96 hr. after administration of vitamin D.

The results reported here indicate that the phosphorus content of rachitic cartilage increases due to the influence of vitamin D preparatory to the onset of calcification. Further work is in progress to determine the effect of vitamin D on the various phosphorus compounds in the healing cartilage.

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Dominant Lethality induced by X-Rays in Haploid and Diploid *Saccharomyces cerevisiae*

In a previous paper[1], evidence was presented for the presence of dominant lethals in X-irradiated haploid yeast cells. Diploid yeast zygotes formed by the conjugation of one irradiated and one unirradiated haploid cell were found to exhibit signs of radiation damage, including swelling, delay in division and death. The damage responsible for inactivation of these half-irradiated zygotes was defined operationally as dominant lethal damage. The present communication describes a continuation of these experiments in which diploid cells homozygous for mating type were employed along with the two haploid cultures previously used. These diploid cells will conjugate with haploid or diploid cells of opposite mating type when placed in direct contact, thus permitting a similar determination of the frequency of dominant lethals in diploid cells. This was of interest because previous studies of the survival of X-irradiated yeast cells of higher ploidy[2] suggested that the frequency of this type of damage might increase with increasing ploidy.

The diploid cells arose spontaneously in the haploid cultures and were isolated with a micromanipulator. The amounts of deoxyribonucleic acid, ribonucleic acid and dry weight per cell for the haploid and diploid cultures were all approximately in the ratio 1 : 2, confirming the expected ploidy of these cultures[3]. The cells used in the experiments were harvested from 24-hr. streak cultures on yeast extract – dextrose agar plates (½ per cent yeast extract, 1 per cent dextrose), suspended in

buffer and maintained at 4° C. until used. Viability was nearly 100 per cent. Single, non-budding cells were isolated with a micromanipulator and paired with similar cells of the opposite mating type as described previously[1]. The medium used for conjugation and growth of the cells after irradiation was yeast extract – dextrose agar (see above) and incubation was at 30° C. Conjugation usually occurred within four to five hours. The frequency of conjugations averaged about 90 per cent and was relatively uninfluenced by irradiation of the parent cells. For each of the following crosses: haploid × haploid (oo), haploid × diploid (oO), diploid × haploid (Oo) and diploid × diploid (OO), one, or the other, or both of the parental cells was irradiated with X-rays (the symbol on the left represents a cell of the α-mating type, that on the right the *a*-mating type; o represents a haploid cell, O a diploid cell. A filled-in circle is used to indicate that the cell was irradiated before pairing). Zygote viability was determined from about 80–100 pairs of cells at a number of dose points (3–7) for each of the twelve possible combinations. The viability of the haploid and diploid cells for vegetative division was determined in a similar manner by the isolation of about a hundred single, non-budding cells for each dose-point studied. The criterion of viability was the ability of the zygote or cell to develop into a colony containing more than forty cells.

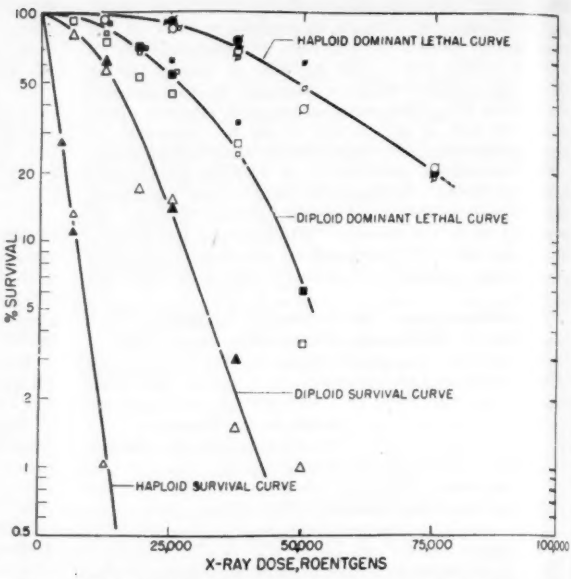

Fig. 1. Haploid dominant lethal curve: ◇, ●o; ◆, o●; ◇, ●O; ◆, O●. Diploid dominant lethal curve: □, ●○; ■, ○●; □, ●o; ■, o●. Diploid survival curve: △, ● — *aa* diploid; ▲, ● — *aa* diploid. Haploid survival curve: △, ● — *a* haploid; ▲, ● — *a* haploid

In agreement with a number of previous studies, the diploid cells of both mating types were found to be less sensitive to X-ray inactivation than the haploid cells. However, the frequency of dominant lethals induced in the diploid cells was considerably greater than in the haploid cells. The results of these experiments are summarized in Fig. 1. Within the accuracy of the experiments, the yield of dominant lethals for either haploid or diploid cells was the same for irradiation of either mating type and in addition was independent of the ploidy of the unirradiated parental cell; that is, ●○ ≡ ○● ≡ ●○ ≡ ○● and ●○ ≡ ○● ≡ ●○ ≡ ○●. Furthermore, there is an approximate dose reduction factor of 2 between the haploid and diploid dominant lethal curves, suggesting that the amount of dominant lethal damage depends on the product of ploidy and dose.

Examination of the results from all crosses where one or both of the parental cells had been irradiated revealed that for a given value of the parameter $p_1D_1 + p_2D_2$ (where p_1 and p_2 are the ploidies of the parental cells and D_1 and D_2 are the respective doses received), the viability of all zygotes except haploid × haploid (●●) was approximately the same. A typical example of this relation is presented in Table 1. Agreement of the results in terms of this parameter would be consistent with the assumption that dominant lethal damage was most important in inactivation of triploid and tetraploid zygotes which had been formed by two irradiated cells. That the haploid × haploid cross (●●) did not fit was considered to be due to the expression of some recessive lethal damage.

Table 1

Cross	p_1	p_2	D_1 (krep)	D_2 (krep)	$p_1D_1+p_2D_2$	Fraction of viable zygotes
●●	2	1	16·7	16·7	50·0	0·49 ± 0·05
●●	2	1	12·5	25·0	50·0	0·54 ± 0·05
●●	2	2	12·5	12·5	50·0	0·52 ± 0·05
●●	2	2	18·75	6·25	50·0	0·46 ± 0·05
●○	2	2	25·0	0	50·0	0·44 ± 0·07
● ○	1	2	50·0	0	50·0	0·47 ± 0·06
● ●	1	1	25·0	25·0	50·0	0·17 ± 0·04

The dependence of dominant lethals on the product of ploidy and dose would be consistent with this damage arising from inviable recombinations of broken chromosome ends—the frequency of breaks would most probably increase with both these variables. However, many critical cellular components of yeast cells[2] are known to increase in integral fashion with ploidy[3], and similar reasoning might be applied to identify the damage with these components. The present experiments do not permit a definite characterization of the dominant lethal damage; they do, however, show that the frequency of this damage increases with the ploidy of the irradiated cell.

A more complete account of this work, including experimental details as well as additional studies with vegetative cells of different ploidies, will appear in a later publication.

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Amino-acid Composition of Hæmoglobin E

In 1955, some of us published the results of the determination of the amino-acid composition of hæmoglobins A, B (also known as S), C and F [1-3]. In that work we used a modification of the column chromatographic method of Stein and Moore. We were recently able to study a family of which some members are carriers of hæmoglobin E. We took advantage of this opportunity to determine the amino-acid composition of this hæmoglobin by the use of the method mentioned in the previous publication[1].

The family came from Indonesia; the father (1) is of mixed British–Javanese extraction (see Fig. 1). He was somewhat anæmic (hæmoglobin 12 gm./100 gm. blood). His hæmoglobin was found to contain 11 per cent of fœtal hæmoglobin, which could be demonstrated by three methods available to us (alkaline denaturation, electrophoresis and chromatography[4]). The presence of about 11 per cent of hæmoglobin F, together with the hæmatological findings, places this otherwise healthy man in the group of the Cooley trait (thalassæmia minor).

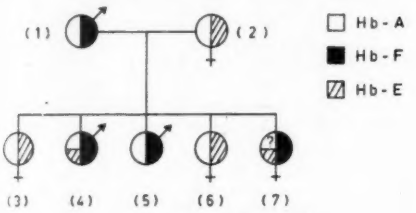

Fig. 1. Pedigree of the family studied

The mother (2) is of mixed Indonesian–Chinese extraction (from which part of China her mother came is unknown); her Indonesian father's family came from Northern Celebes. In the blood of this healthy woman an abnormal hæmoglobin was detected and shown by paper electrophoresis to be hæmoglobin E [5-7]. The percentage of this hæmoglobin E was 38 per cent. Of the five children of this marriage, numbers 3 and 6 had hæmoglobin A and E in their blood, the percentage of hæmoglobin E being respectively 27 and 44 per cent. The blood of one child (5) showed a small percentage of fœtal hæmoglobin (6 per cent), as did the father's blood.

Another child (4), a boy of five years, the only member of the family with a severe anæmia, showed the clinical picture of a moderately severe Cooley's anæmia. His blood contained nearly 41 per cent of fœtal hæmoglobin, 38 per cent of hæmoglobin E and 21 per cent of normal hæmoglobin. The youngest child (7) is now seven months of age. Her blood still contains 71 per cent of fœtal hæmoglobin. In a normal child of that age only traces of fœtal hæmoglobin can be detected. Besides this fœtal hæmoglobin, hæmoglobins E and perhaps A could be detected. Similar families with thalassæmia minor and hæmoglobin E trait in their ancestry and with members whose hæmoglobin was a mixture of hæmoglobins E and F have been described previously[5,7].

As we were unable to separate quantitatively hæmoglobins A and E, we had to use mixtures of both hæmoglobins for our amino-acid determinations. We used the hæmoglobin of cases 2, 3 and 6 containing, respectively, 38, 27 and 44 per cent hæmoglobin E.

Table 1. Amino-acid Composition of 48-hr. Hydrolysates of Different Hæmoglobin Samples
(The values are given as gm. per 100 gm. protein)

Amino-acid	Hæmoglobin A	Patient 2 (38 per cent hæmoglobin E)	Fraction patient 4 (65 per cent hæmoglobin E)
Aspartic	10·5	10·3	10·35
Threonine	5·5	5·45	5·7
Serine	4·45	4·75	4·45
Glutamic	7·25	7·8	7·0
Proline	4·95	4·65	4·9
Glycine	4·55	4·75	4·45
Alanine	9·95	10·3	9·95
Cystine	1·0	1·05	1·15
Valine	10·9	10·8	11·0
*iso*Leucine	0·35	0·4	0·35
Leucine	15·15	14·9	14·3
Tyrosine	3·85	4·15	3·75
Phenylalanine	7·85	7·6	7·85
Lysine	9·9	9·8	9·95
Histidine	8·3	8·25	8·25
Arginine	3·35	3·65	3·25

The hæmoglobin of patient 4 was then re-tested after the hæmoglobin F had been removed by means of column chromatography. After this procedure, the hæmoglobin E content was 65 per cent, the remainder being hæmoglobin A. The analysis was done as previously described[1]. In Table 1 the results for cases 2 and 4 are given. Those of cases 3 and 6 are in agreement with the two mentioned here.

These results make it likely that the amino-acid composition of hæmoglobin E is the same as that of normal hæmoglobin. The same is the case for hæmoglobin B. The N-terminal residues of hæmoglobin E are the same as those of the hæmoglobins A, C and B, namely, five valine groups[8]. These findings make it probable that man can synthesize different hæmoglobins which have the same amino-acid composition and the same N-terminal residues, but differ in some physical properties. The occurrence of each of these hæmoglobins is dependent on the existence of one abnormal gene.

Protein synthesis seems to occur under the direct influence of one or more genes. Therefore it is possible that these relatively small differences in structure between hæmoglobins A, E and B which are caused by the presence of one abnormal gene can provide us with some information about the mode of action of these genes in the synthesis of hæmoglobin. Two different possibilities arise: first, the indistinguishable amino-acid composition and the identical N-terminal residues point to an identical sequence of the amino-acids in the polypeptide chains in these different hæmoglobins. If this is true, the differences between these hæmoglobins must be the result of differences in folding of the polypeptide chains and of differences in bonds between these chains. In this case one might conceive that one group of genes is responsible for the synthesis of the polypeptide chains and that a separate gene or a small group of genes regulates the folding of those chains and the bonds between them. This would make protein synthesis in at least two phases likely.

A second possibility is that there are in fact differences in the amino-acid sequences in the polypeptide chains and that these differences are the cause of the differences between hæmoglobins A, E and B. Consequently a different folding of the polypeptide chains must be assumed in the different hæmoglobins. Hæmoglobin C differs from hæmoglobins A, E and B in lysine content. This points to the possibility that the gene responsible for the formation of hæmoglobin C influences the synthesis of the polypeptide chains. In view of the great differences in amino-acid

composition between hæmoglobins A and F, one must assume that the synthesis of these two proteins is regulated by quite different groups of genes.

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Staining of Wool by Bacterial Pigments

Staining of the fleece by bacterial pigments has been described[1], and a number of colours have been attributed to a variety of organisms. Recent investigations on the staining of Corriedale fleeces during periods of wet weather have shown that several stains similar to some of those described in previous work can be caused by the oxidation or reduction products of the pigment pyocyanine, produced by a single species *Pseudomonas aeruginosa* (Schroeter) Migula.

Growth and pigment production by the organism are dependent upon the rate of drying of the fleece from saturation[2]. At saturation, the *p*H of basal fleece of the susceptible type is 5·6–6·0, and this *p*H has been found to be the optimal for rapid production of pyocyanine in culture. Under such conditions of wetness and *p*H the fibres are stained green. However, after prolonged wetting, colour banding occurs in the fleece, and brown and red bands appear in succession above a green band. Upon drying, banding disappears and a yellowish-brown or green colour results.

P. aeruginosa was isolated as a nearly pure culture from wool showing green staining; and after purification it was grown in a synthetic culture medium containing phosphate, sulphate, magnesium and ferric ions with glycerol and urea. Growth for twelve days at 22° C. gave maximum production of pyocyanine, at which stage the cultures were passed through a Seitz filter. Extraction of the filtrate with chloroform yielded a coloured solution which was later separated into pyocyanine (blue), hemipyocyanine (yellow) and pyorubrin (red) by elution through an alumina column. The aqueous layer also retained pigments and these fluoresced in ultra-violet light. Separation of pyocyanine is also achieved by converting it to its red salt when the chloroform extract is shaken with 1 per cent hydrochloric acid. The salt is taken up into the aqueous layer, and hemipyocyanine and pyorubrin remain in the chloroform layer.

Reduction of aqueous pyocyanine solution over the entire *p*H range results in the breakdown of pyocyanine in different ways according to the initial *p*H of the solution. At *p*H 5·6 and above, breakdown of the blue solution is direct to the leuco-base. Between *p*H 5·6 and 4·8, when the colour of the solution is violet, the breakdown is by two steps, to green and then to the leuco-base. Below *p*H 4·8 when the solution is red, reduction is by three steps, yellow to green and finally to the leuco-base. Pigment solutions of *p*H 4·8–5·6 are easily reduced to green, whereas at *p*H's below 3·5 the stepwise reduction is more difficult. These results are in accord with those of Friedheim and Michaelis[3] except that these authors make no reference to the yellow reduction product which has been found to be the first step in the reduction of pyocyanine in the lower *p*H ranges.

Of all the pigments isolated, only hemipyocyanine and pyocyanine have been found to stain wool fibres. The colour produced in the fibres was dependent upon the *p*H of the stain solution. Table 1 shows the results of such tests.

When pigment is absorbed into the fibre from an alkaline dye solution, the change in colour from blue to the leuco-base shows that reduction of the pyocyanine molecule has occurred. However, oxidation to the blue colour occurs upon washing. Staining between *p*H 5·8 and 5 results in a decrease of blue and an increase of green in the fibre. The green coloration is, however, formed in the fibres in solution, and subsequent oxidation does not change it. Thus it appears that over this particular small range of *p*H values reduction of the oxidized pyocyanine molecule has occurred, causing the green reduction product to be formed. The dyestuff produced remains within the fibre on washing in warm distilled water and in 1 per cent hydrochloric acid, but the latter converts the green coloration to a red colour similar to that produced in fibres dyed in solutions below *p*H 3·0 : this change is reversible. Thus it appears possible that the red band at distal staple levels, formed after prolonged wetting of the fleece, is caused by acidic degradation products of the tip[4]. Neither the green- nor the red-dyed wool can be changed to blue.

It appears that the pyocyanine molecule is retained within the fibre but not due to bonding, whereas

Table 1. Clean Scoured Wool stained with Pure Pyocyanine in 0·1 *M* Phthalate Buffer at 37° C. for 48 hr.

*p*H of dye solution	Colour of dye solution	Colour of stained wool		Wool washed in distilled water (80° C.)	Wool washed in 1 per cent hydrochloric acid (warm)
		In dye solution	After washing in distilled water (20° C.)		
8·4 and above	Blue	Colourless	Blue	All absorbed pyocanine removed from fibres	All pigment removed as red acid salt
7·4	Blue	Colourless	Blue	,,	,,
5·8	Blue	Green	Blue-green	Pyocyanine partly removed but green remains in fibres	Pyocyanine removed as acid salt, green pigment turns red and remains in fibre
5·0	Violet	Green	Green	No pigment removed into solution	No acid salt removed but green pigment turns red
3·0	Red	Yellowish-brown	Yellowish-brown	,,	,,
2·0	Red	Red	Red	,,	,,

the green and red pigments, as shown by the stability and loss of indicator reaction at alkaline *p*H values, appear to be bonded to the fibre. It is likely that the combination of an amino-group and the dye molecule will result in the formation of an aminophenazine compound having dyestuff properties.

We wish to thank Prof. J. A. R. Miles, of the Medical School, Otago University, for confirming our identification of the bacterium.

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A. P. Mulcock

Canterbury Agricultural College,
University of New Zealand,
Christchurch, New Zealand.

[1] Seddon, H. R., *Sci. Bull. Dep. Agric. N.S.W.*, No. 54 (1937). Belschner, H. G., *Sci. Bull. Dep. Agric. N.S.W.*, No. 54 (1937).
[2] Fraser, I. E. B. (in the press).
[3] Friedheim, E., and Michaelis, L., *J. Biol. Chem.*, **91**, 355 (1935).
[4] Speakman, J. B., and McMahon, P. R., *J. Sci. Tech. N.Z.*, **20**, 248B (1941).

Protein Denaturation in Heavy Water

The increasing availability of deuterium oxide resulting from developments in nuclear energy renders it opportune to reopen the general question of the effects of deuteration on biological activity. Numerous investigations have utilized deuterium as a tracer. There are few quantitative studies, however, which help provide a basis for an understanding of the profound consequences of extensive deuteration on living organisms. To this end, we have now carried out experiments on the denaturation of ovalbumin in 99·6 per cent heavy water.

The denaturation of ovalbumin by highly concentrated urea solutions has been described in detail by Simpson and Kauzmann[1] and affords a reasonably controlled system adapted to comparative kinetic studies in heavy water and water. Following closely the experimental procedures and methods of analysing the data described by Simpson and Kauzmann, we have made polarimetric measurements of the denaturation of ovalbumin in heavy-water solutions which are 7–8 molar in deuterourea. Under these conditions a markedly slower rate of denaturation is observed in heavy water as compared to water.

The polarimetric measurements were performed in 99·6 per cent heavy water in water-jacketed polarimeter tubes 2 dm. long; the temperature was maintained at 30·0° C. ± 0·2° C. A Rudolf high-precision model 80 polarimeter equipped with a monochromator supplying light of wave-length 5893 A. was employed. Reagent grade urea was exchanged with 99·6 per cent heavy water four times yielding a product urea-d_4, which gave by Kjeldahl determination N, 43·5 per cent (calculated for ND_2COND_2, N, 43·7 per cent). Stock solutions of ovalbumin in heavy water were prepared by dissolving four-times crystallized ovalbumin (obtained from Pentex Inc., Kankakee, Illinois) in 99·6 per cent heavy water and centrifuging the solution for two hours at 31,000 *g*. Morowitz and Chapman[3] have shown that all exchangeable hydrogens in a globular protein are replaced by deuterium atoms within 20 min. from the time of dissolution in heavy water. Protein concentration was determined in the solutions by dry weight and spectrophotometrically, using for ovalbumin E (1%, 1 cm.) = 7·5 at 279 mμ. In order to provide a valid basis for the comparison of our heavy-water measurements with observations in ordinary water, it is essential that the same preparation of crystallized ovalbumin be used for the kinetic measurements in both solvents.

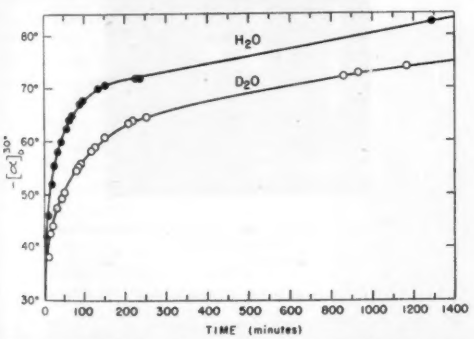

Fig. 1. Change in optical rotation accompanying the urea denaturation of ovalbumin solutions in water and heavy water. Protein concentration: 2 per cent; urea, 7·87 *M*; urea-d_4, 7·89 *M*. Buffer in both solutions: 0·035 *M* sodium phosphate, *p*H ~ 8·0. Note time-scale change at 600 min.

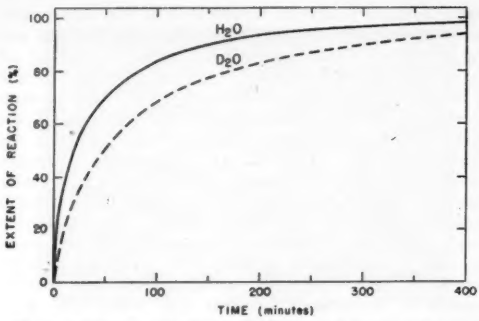

Fig. 2. Comparison of rates of denaturation in water and heavy water. Extent of reaction (initial fast reaction) is calculated at each point by the relationship:

$$\% \text{ reaction completed} = \frac{[\alpha] \text{ observed} - [\alpha] \text{ initial}}{[\alpha] \text{ final} - [\alpha] \text{ initial}}$$

In Fig. 1 are presented the specific rotations $[\alpha]_D^{30°}$ for both water and heavy-water solutions. Neither the kinetic data obtained by Simpson and Kauzmann in water nor the data given here for heavy water are capable of representation by a simple first- or second-order graph. The analytical procedure developed by Simpson and Kauzmann has been applied to Fig. 1, yielding for the heavy-water data $-[\alpha_f] = 70°$, and for water, $-[\alpha_f] = 75°$. These final optical rotation values can be used to construct Fig. 2, from which the characteristic half-times of reaction can be determined: in heavy water, $t_{1/2} = 50$ min.; in water, $t_{1/2} = 18$ min. It thus appears that the rate of denaturation in heavy water is only about one-third that in ordinary water.

A surprising observation in the course of this work is the finding that the specific rotations $[\alpha]_D^{30°}$ of ovalbumin in pure water and heavy water are practically identical. For ovalbumin in heavy water we find $-[\alpha]_D^{30°} = 29·7 \pm 0·6°$, for water, 30·0 ± 0·3° C.; Simpson and Kauzmann give 30·0° for the specific rotation of ovalbumin in water. The substitution of deuterium for hydrogen thus does not lead to equilibrium structural alterations by the criterion of optical rotation.

On the basis of the results described here it cannot be decided whether the marked slowing down in the rate of denaturation in the protein–urea–heavy

water system is due to alterations in the interaction between the protein and the solvent, the protein and the urea, or the solvent and the urea. However, all these interactions involve hydrogen bonding, and it would appear plausible to attribute the change in rate to small differences in the strength of the hydrogen bonds when hydrogen is replaced by deuterium. Thus, if the replacement of hydrogen by deuterium in hydrogen bonds existing between the protein and solvent leads to slightly more stable bonds, because of zero-point energy considerations, then multiplying the slight stabilization per bond by many bonds may produce the observed slowing down. In any event, it would appear that further studies in deuterated systems may contribute to a clearer understanding of the role of hydrogen bonding in maintaining protein configuration.

This work was carried out under the auspices of the U.S. Atomic Energy Commission.

Robert H. Maybury
University of Redlands,
Redlands, California.

Joseph J. Katz
Chemistry Division,
Argonne National Laboratory,
Lemont, Illinois.

Nov. 28.

[1] Simpson, R. B., and Kauzmann, W., *J. Amer. Chem. Soc.*, **75**, 5139 (1953).
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Assay of Possible Carcinogenic Hydrocarbons from Cigarette Smoke

Recently, Cooper and Lindsey[1] and Seelkopf[2] described the identification and assay of the carcinogen 3,4-benzpyrene and other polycyclic hydrocarbons in a neutral aromatic fraction of cigarette smoke. These investigators, in the attempt to reconstruct conditions complying with those present in normal human cigarette smoking, smoked cigarettes in an automatic fashion which effected strictly regular intermittent puffing.

The present communication describes a similar investigation of cigarette smoke under conditions of smoking and collection of smoke products which differed from those used by Cooper and Lindsey and by Seelkopf. The time taken to smoke a cigarette of average weight 1·1 gm. to a butt of approximately 1·4 cm. was varied between 7 and 12 min.; 2–4 sec. draws were made during the course of smoking. It was assumed that varying the tempo of smoking as indicated coincided more with reality than regular and 'average' smoking. The smoke products were collected in acetone chilled to − 70° C. 500 cigarettes, used in the present operation, yielded 15·0 gm. of smoke products.

A neutral aromatic fraction was prepared and fractionated by adsorption chromatography using alumina, silica gel and 'Florisil'. The chromatographic analysis was followed by inspection of columns and eluates under a filtered ultra-violet light, and eluates were screened by fluorescence spectrography. Ultra-violet absorption spectrophotometry was carried out for qualitative and quantitative determination of polycyclic hydrocarbons as an adjunct to fluorescence spectrography. In all determinations cyclohexane was used as solvent.

The range of polycyclic hydrocarbons present was found to be essentially the same as that demonstrated by Cooper and Lindsey[1b], pyrene being present in greatest concentration. In addition, other hydrocarbons were detected. Azulene, postulated by the London workers as likely to be present, was indicated in an initial eluate by its spectrum in the near ultra-violet and visible range. The presence of 1,2-benzanthracene, detected by fluorescence spectrography, was substantiated by its ultra-violet absorption spectrum, giving an inflexion point at 384·5 mμ and peaks at 299, 288 and 276 mμ. It was present to the extent of 1 μgm. approximately. 3,4-Benzpyrene, the presence of which was established by both fluorescence spectrography and ultra-violet absorption spectrophotometry, was estimated at 7·4 μgm. by peak-height measurement against a standard 3,4-benzpyrene at 385 mμ. This concentration of 3,4-benzpyrene agreed with that estimated by Seelkopf. A rechromatography of the 3,4-benzpyrene fraction on activated alumina revealed the presence of two further components in low concentration, which had a blue-violet fluorescence in ultra-violet light and which were more strongly adsorbed than the 3,4-benzpyrene; their fluorescence spectra are shown in Fig. 1. One, spectrum IV, exhibits a slight hypsochromic shift with apparently increased fine structure, whereas the other, spectrum VI, shows a slight bathochromic shift relative to the 3,4-benzpyrene spectrum, such as may be brought about when a position of low free valence is substituted by an alkyl group (*vide* Schoental and Scott[3]). The absorption data in Table 1 demonstrate that the apparent shift of the shortest fluorescence band is paralleled by the shift in the longest absorption band, an approximate mirror-image relationship existing between the fluorescence and absorption spectra[3,4].

Table 1. Absorption Maxima (mμ)

3,4-Benzpyrene	403		385		375
Fluorescence spectrum IV	401	394	384	389	373
,, ,, VI	404·5	390	387		376

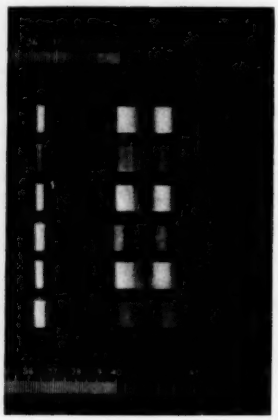

Fig. 1. Fluorescence spectra of three compounds isolated from cigarette smoke

No.	Spectrum	Exposure time (min.)
I	Standard 3,4-benzpyrene (0·1 mgm. per 100 ml.)	3
II	3,4-Benzpyrene derived from cigarette smoke	3
III	Standard 3,4-benzpyrene	3
IV	Unidentified *A*	8
V	Standard 3,4-benzpyrene	3
VI	Unidentified *B*	15

All samples are in cyclohexane

The quantitative estimation of the 3,4-benzpyrene and 1,2-benzanthracene is regarded as having semi-quantitative significance. The latter compound, which satisfies the frontier electron density index for carcinogenicity of Nagata *et al.*[5], is shown by Steiner[6] to be of 'medium' carcinogenic potency. The concurrent action of the 1,2-benzanthracene, 3,4-benzpyrene and the two compounds, the spectra of which resemble that of benzpyrene, on the animal body is difficult to assess. A wide range of effects, from inhibition through summation to synergism, is conceivable (*vide* Steiner[6]).

I am grateful to Dr. P. R. Peacock, director of research, and Mr. J. G. Chalmers, for helpful advice, and to Mr. S. Breslin for printing and mounting of spectra. Further details, including temperatures recorded during the smoking, will appear elsewhere.

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Cancer Research Department,
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Nov. 30.

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Influence of a Magnetic Field on Thermal Convection Patterns

Thermal instability during the chemical silvering of glass produces Bénard convection patterns in the deposited silver layer. An unstable condition produced by cooling the silver solution to about 10° C., pouring it over the top surface of glass plates at 25° C. arranged horizontally, so as to produce a layer about 3 mm. thick, gave silver patterns as shown in Fig. 1. A very unusual and pronounced difference occurred in the details of the shapes of the convection patterns when formed in the presence of a magnetic field.

When the glass was cooled to the same temperature as the silvering solution and heated from below at two points by the poles of an electromagnet at room temperature, a different type of convection occurred in these locally heated areas. The convection lines centred toward the heated regions, as shown in Fig. 2 for two directions of the magnet current, the magnet position unchanged. The shape of the convection lines disclosed an unusual effect, namely, a characteristic difference between the patterns over the north and south poles. The radiating lines at the north pole disclose little curvature and stream toward a common focus at the centre, whereas at the south pole the lines have greater curvature and do not meet at a common centre.

When an alternating current (60 ~) was applied to the electromagnet, the convection patterns appeared the same over both pole pieces.

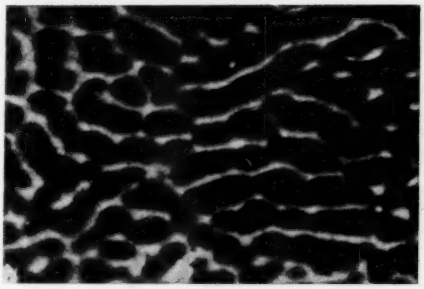

Fig. 1. Bénard cell patterns on silvered glass surface. × 2

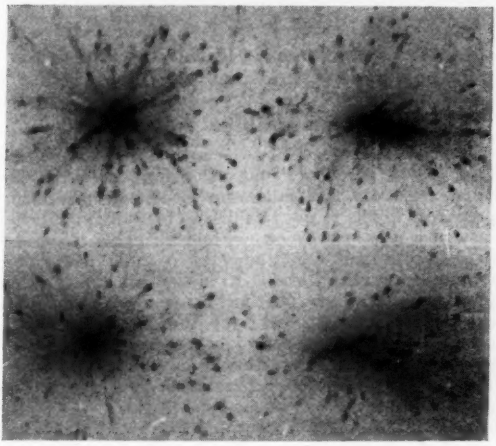

Fig. 2. Convection lines around poles of electro-magnet; 2,000 gauss field. × 3. Upper, north pole left, south pole right; lower, south pole left, north pole right

Patterns using a permanent magnet with large circular pole faces are shown in Fig. 3. The north pole lines are straighter and converge toward a central spot, whereas the lines at the south pole form at the periphery of the heated area and have greater curvature. There is a provocative similarity between these patterns and sunspot patterns. Especially interesting are sunspots that have mutual line patterns as shown by Alfven[1]. The magnetic field itself may

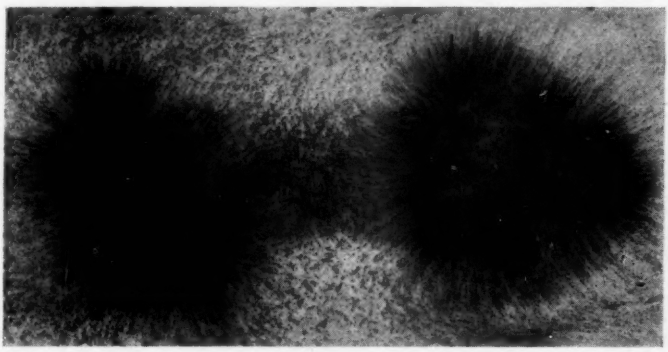

Fig. 3. Permanent magnet, north pole left, south pole right; 1,400 gauss field; pole faces 4 cm. diameter. × 0·6

have an inhibitive effect on the formation of the Bénard convection, as was recently demonstrated by Nakagawa[2]. Chandrasekhar[3] also points out that with motions at right angles to the magnetic field, the 'closing in' of the lines to produce the usual Bénard cell patterns becomes increasingly difficult. He also mentions that the lines around sunspots (photographed in hydrogen radiation) may be due to the inhibitive effect of their magnetic fields.

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Toledo 5, Ohio. Oct. 17.

[1] *Sci. Amer.*, **186**, No. 5, 26 (1952).
[2] *Nature*, **175**, 118 (1955).
[3] *Phil. Mag.*, **43**, 501 (1952).

Relation between the Initial Instantaneous Extension in Creep and the Yield Stress and Coefficient of Work-hardening in Polycrystalline Metals

In the course of work on the creep of polycrystalline lead (99·99 per cent) under constant stress in the range 20–105° C., a full account of which is being prepared, it was found possible to measure the initial instantaneous extension with reasonable accuracy at the lower end of the temperature scale. At higher temperatures the period of low strain-rate, which intervened between the termination of the initial extension and the onset of the transient creep, diminished and the accuracy of measurement suffered in consequence. Nevertheless, as can be seen from Fig. 1, it was possible to establish that the tensile stress σ was related to the initial tensile strain ε by the work-hardening law characteristic of polycrystalline metals of cubic symmetry:

$$\sigma^2/\varepsilon = \chi(T)$$

where $\chi(T)$ is the temperature-dependent coefficient of work-hardening.

Jacquet's electron-micrographic evidence[1] of the formation of dislocation 'pile-ups' at grain boundaries of slightly deformed alpha-brass, but particularly the uniformity of the spacing between adjacent pile-ups, suggested that the hardening of the brass was of the interaction type, treated theoretically by Mott[2], which also leads to a parabolic strain-hardening law. An attempt was therefore made to apply this theory of interaction-hardening to the results obtained in the present work.

If, to conform with the method of testing, the shear stress is replaced by $\frac{1}{2}\sigma$, and the tensile strain is put equal to the shear strain, Mott's theory gives

$$\chi = G^2bn/\pi^2L$$

where $2L$ is the mean grain diameter, b the interatomic spacing in the slip direction, G the shear modulus and n the number of dislocation in the pile-up. According to Mott,

$$n \simeq (2\pi L/Gb)\,\tau_y$$

where τ_y is the yield stress in shear of the undeformed metal. Since, judging from Jacquet's results, n does not appear to be significantly dependent on L for grain-sizes as used by him, and also in the work here discussed, it follows that τ_y should be approximately inversely proportional to the grain-size. Further, from the above relations,

$$\chi \simeq (2/\pi)\,G\tau_y$$

which is independent of n. Now, very slow creep in polycrystalline lead is observed at tensile stresses[3] of about 30 kgm./cm.², so that τ_y is less than 15 kgm./cm.² at 25° C., but must be greater than 3 kgm./cm.², which is the yield stress in shear for single crystals of high purity[4]. Therefore, taking $\tau_y = 10$ kgm./cm.² and $G = 5 \times 10^4$ kgm./cm.², the last equation yields $\chi = 3{\cdot}2 \times 10^5$ kgm./cm.², which is in satisfactory agreement with the values obtained from the slopes of the lines in the left-hand figure: $2{\cdot}8 \times 10^5$ kgm./cm.² for $2L = 0{\cdot}11$ mm., and $1{\cdot}7 \times 10^5$ kgm./cm.² for specimens with grain diameters $2L = 0{\cdot}04$ and $0{\cdot}06$ mm. Owing to poor resolution of the experimental results in the last two cases, separate χ-values were not determined for these grain-sizes. It is apparent, however, that the ratio of grain sizes is close to the corresponding ratio of χ^{-1}-values. The value of n which is required to satisfy these results is of the order of 100 at 25° C., which is comparable with the mean value of the number of dislocations per pile-up as shown in Jacquet's micrographs. The comparatively high temperature-dependence of χ, indicated by the results in Fig. 1 (right), is of about the same magnitude as that of the yield stress in shear of lead single crystals in the same temperature-range[4].

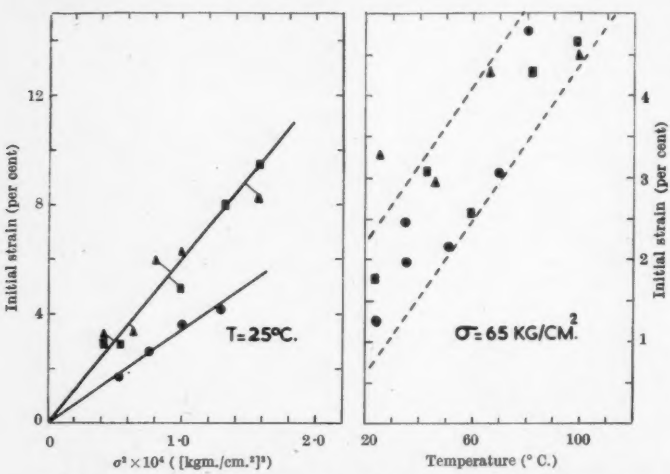

Fig. 1. Mean grain diameter: ●, 0·11 mm.; ▲ 0·06 mm.; ■, 0·04 mm.

Paul Feltham

Department of Metallurgy,
University, Leeds, 2. Dec. 5.

[1] Jacquet, P. A., *Acta Met.*, **2**, 752 and 770 (1954).
[2] Mott, N. F., *Phil. Mag.*, **43**, 1115 (1952); **44**, 742 (1953).
[3] Tyte, L. C., *Proc. Phys. Soc.*, **51**, 203 (1939).
[4] Neurath, P. W., and Koehler, J. S., *J. App. Phys.*, **18**, 79 (1951).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Wednesday, April 4

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. L. Clegg: "Fuel and Power Surveys".*

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 6.15 p.m.—Scientific Papers.

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Mr. R. Hill: "The Determination of 4-Chloro-2-methylphenoxyacetic Acid in MCPA by a Differential Refractometric Method"; Mr. F. Franks: "Paper Chromatography with Continuous Change in Solvent Composition. Part 1: Separation of Fatty Acids. Part 2: Separation of Surface Active Agents".

Thursday, April 5

INSTITUTION OF ELECTRICAL ENGINEERS (in conjunction with the BRITISH NUCLEAR ENERGY CONFERENCE, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. A. B. Gillespie: "The Control and Instrumentation of a Nuclear Reactor"; Mr. R. J. Cox and Mr. J. Walker: "The Control of Nuclear Reactors"; Mr. W. Abson and Mr. F. Wade: "Reactor Control Ionization Chambers"; Mr. G. E. Lockett: "Some Design Aspects of Nuclear Reactor Control Mechanisms".

Thursday, April 5—Friday, April 6

INSTITUTE OF PHYSICS, EDUCATION GROUP (at 47 Belgrave Square, London, S.W.1), at 10 a.m. daily—Conference on "The Teaching of Atomic and Nuclear Physics".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Auditorium, The Wellcome Building, 183–193 Euston Road, London, N.W.1)—Symposium on "Hypotensive Drugs and the Control of Vascular Tone in Hypertension".

Friday, April 6

INSTITUTION OF MECHANICAL ENGINEERS, INTERNAL COMBUSTION ENGINE GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Mr. G. B. R. Feilden, Mr. J. D. Thorn and Mr. M. J. Kemper: "A Standard Gas Turbine to Burn a Variety of Fuels".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Discussion on "The Importance of Visual Aids in the Teaching of Advanced Radio and Electronic Engineering", opened by Mr. R. H. Garner.

Saturday, April 7

UNITED KINGDOM COMMITTEE FOR THE WORLD HEALTH ORGANIZATION OF THE UNITED NATIONS (in the Beveridge Hall, Senate House, London University, Malet Street, W.C.1), at 2.30 p.m.—Meeting to celebrate "World Health Day". Principal Speakers: Sir Russell Brain, Bt., and Sir Andrew Davidson.

BRITISH INTERPLANETARY SOCIETY (in the York Hall of Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Mr. J. Foley, Mr. E. White and Mr. R. Wilkins: "Power Supplies and Telemetry for Instrument-Carrying Artificial Satellites".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

BIOCHEMIST, Senior Grade (with a first- or second-class honours degree) IN THE PATHOLOGICAL DEPARTMENT—The Secretary, Liverpool Radium Institute, 1 Myrtle Street, Liverpool 7 (April 7).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Leeds 2 (April 9).

DEMONSTRATOR (with a good honours degree in physiology or biochemistry) IN PHYSIOLOGY—The Registrar, The University, Manchester 13 (April 10).

RESEARCH ENGINEERS (with a good honours degree or corporate membership of one of the principal Engineering Institutes), for the development of plant manufacturing smokeless and metallurgical fuels—The National Coal Board, Coal Research Establishment, Stoke Orchard, near Cheltenham, Glos, quoting SS/236 (April 11).

ASSISTANT STATISTICIAN (with a pass degree, diploma, or equivalent qualification, and preferably with a knowledge of both mathematics and horticulture (or botany)), for the examination and analysis of experimental data—The Secretary, East Malling Research Station, near Maidstone, Kent (April 14).

LECTURER IN PHYSICS—The Registrar, The University, Reading (April 14).

LECTURER (honours graduate in physics or chemistry) IN TEXTILE CHEMISTRY—The Registrar, College of Technology, Manchester 1 (April 14).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, The University, Manchester (April 16).

LECTURER (with a good honours degree) IN CHEMICAL ENGINEERING—The Registrar, King's College, Strand, London, W.C.2 (April 16).

MATHEMATICIAN or AERODYNAMICIST (with a first- or second-class honours degree or equivalent, and preferably with a knowledge of airworthiness requirements and operating regulations) at the Ministry of Supply Headquarters in London, to assess the suitability of civil aircraft projects for commercial operations, including estimation of aircraft performance and economics of operation—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.99/6A (April 16).

RESEARCH FELLOW IN ECONOMIC STATISTICS—The Registrar, The University, Manchester 13 (April 16).

LECTURER (with a good honours degree in electrical engineering or physics) IN ELECTRICAL ENGINEERING with special reference to Electronics—The Registrar, King's College, Strand, London, W.C.2 (April 18).

LABORATORY SUPERINTENDENT FOR PHARMACOLOGY AND VETERINARY PHYSIOLOGY, and a TECHNICIAN IN PATHOLOGY, at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 20).

ASSISTANT LECTURER or LECTURER (preferably with qualifications in applied mathematics) IN MATHEMATICS—The Registrar, Trinity College, Dublin (April 21).

LECTURER (Grade II) IN MATHEMATICS at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 23).

LECTURER (with teaching experience, and preferably a good honours degree in geography) IN EDUCATION—The Secretary, The University, 38 North Bailey, Durham (April 28).

LECTURER or SENIOR LECTURER IN GENETICS—The Registrar, The University, Liverpool (April 30).

LECTURERS IN EXPERIMENTAL PHYSICS—The Secretary of University Court, The University, Glasgow (April 30).

PROFESSOR OF EXPERIMENTAL PHYSICS at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, April 30).

SENIOR LECTURER IN PHARMACOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

RESEARCH PHYSICIST (with Ph.D. or equivalent in physics and experience in cryogenic research) IN THE DIVISION OF PHYSICS, National Standards Laboratory, Commonwealth Scientific and Industrial Research Organization, Sydney, New South Wales, Australia, for experimental research in the Division's cryogenic group—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 770/116 (May 1).

READER IN CLINICAL PATHOLOGY at Guy's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 2).

READER or SENIOR LECTURER IN APPLIED MATHEMATICS at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, May 7).

LECTURER (preferably with experience in the theory of machines and/or strength of materials) IN MECHANICAL ENGINEERING at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Sydney, May 15).

ASSISTANT (preferably with experience in plant pathology) TO THE MYCOLOGIST at Cambridge, and an ASSISTANT REGIONAL TRIALS OFFICER (preferably with practical experience in crop production), at Leeds University Farm, Headley Hall, Yorks—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

BIOCHEMICAL TECHNICIAN IN THE PHYSIOLOGY DEPARTMENT of the Medical School, to take charge of the preparation of materials for biochemical classes for medical, dental and science students, and to assist if required in research work of a biochemical nature—Prof. A. A. Harper, Department of Physiology, The Medical School, King's College, Newcastle-upon-Tyne 1.

BIOCHEMIST (with a Ph.D. or its equivalent from a recognized university, and preferably a knowledge of manometric and tracer techniques) to study nutrition and metabolism of marine bacteria and various problems concerned with the biochemistry of fish—The Acting Director, Fisheries Research Board of Canada, Technological Station, Vancouver 2, B.C., Canada.

CHAIR OF CIVIL ENGINEERING—The Secretary-Treasurer, Royal Technical College, George Street, Glasgow, C.1.

CHEMICAL ENGINEER (with a Master's or Bachelor's degree in chemical engineering, and preferably some research experience) to initiate engineering research on problems concerned with the processing of fish, and to assist in engineering work already in progress—The Acting Director, Fisheries Research Board of Canada, Technological Station, Vancouver 2, B.C., Canada.

COMPUTOR (woman, with good mathematical qualifications), to assist with scientific research in the Physics Department—The Assistant Secretary, University College London, Gower Street, London, W.C.1.

CROP ECOLOGIST (with either (*a*) a good honours degree in botany, with postgraduate training in agriculture, or agricultural botany, and a sound grasp of statistics, particularly those concerning crop sampling; or (*b*) a degree in mathematics with experience of statistical techniques and some knowledge of, and interest in, biometry or botany) in the Department of Soil and Land-Use Survey, Gold Coast, to collect yield data for various crops grown on different soils—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.79/13/03.

ELECTRICAL ENGINEERS and PHYSICISTS (with a first- or second-class honours degree in electrical engineering or physics with a bias towards electronics, and preferably with experience of airborne radar systems) at a Ministry of Supply Establishment in Norfolk, for development and adaptation of radio equipment pulse techniques, including aerials, power supplies and displays—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.105/6A/BN.

LABORATORY TECHNICIAN IN PHYSICS—The Clerk to the Governors, Mid-Essex Technical College, Market Road, Chelmsford.

LABORATORY TECHNICIAN (with appropriate qualifications, and preferably some training in biochemistry) IN THE CLINICAL PATHOLOGICAL LABORATORY—The Secretary, The National Hospital, Queen Square, London, W.C.1.

LECTURER (specializing in palæontology–stratigraphy) IN GEOLOGY, and a LECTURER (specializing in petrology–mineralogy) IN GEOLOGY—The Acting Dean, College of Arts and Science, Baghdad, Iraq.

ORGANIC CHEMIST (Scientific Officer grade) (with at least a second-class honours degree with not less than a year's experience of research in organic chemistry, and preferably with an interest in the chemistry of natural products and/or microbiology) at the Colonial Microbiological Research Institute, Trinidad, to conduct research into chemical problems arising in the course of the Institute's programme, involving work on antibiotics and other products of micro-organisms, fermentation of the cocoa bean, plant polyphenols, etc.—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.208/209/04.

ORGANIC CHEMIST (with a degree in chemistry or biochemistry and postgraduate laboratory or research experience) AT THE LOW TEMPERATURE RESEARCH STATION, Cambridge, to work on the chromatographic analysis of potatoes in relation to blackening—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

PHYSICIST (with a good degree or equivalent, and a good knowledge of classical physics, with electronics) for work on problems of tension control of the yarns in lace manufacture; and a CHEMIST (with a good degree or equivalent in chemistry, and preferably some knowledge of textile chemistry) for work on problems of dimensional stability of lace fabrics—The Director, Lace Research Association, Glaisdale Drive West, Bilborough, Nottingham.

PHYSICISTS or CHEMISTS (with an honours degree) for work which covers a wide range of problems connected with the manufacture and use of ceramic materials—The Director of Research, British Ceramic Research Association, Queen's Road, Penkhull, Stoke-on-Trent.

SENIOR LECTURER IN PHYSIOLOGY AND PHARMACOLOGY at the Technical College, Bradford—The Director of Education, Town Hall, Bradford.

SENIOR LECTURER (with high academic qualifications, and able to teach physical chemistry up to B.Sc. special chemistry degree standard and also able to direct research) IN PHYSICAL CHEMISTRY—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Scientific Proceedings of the Royal Dublin Society. Vol. 27 (N.S.), No. 2 (December 22nd, 1955): Whiting (*Gadus merlangus* L.) in Irish Waters. By Hazel W. Elkin. Pp. 17–34. 5*s*. No. 3 (December 22nd, 1955): The Granites of the Western Mourne Mountains, County Down. By C. H. Emeleus. Pp. 35–50+plates 1 and 2. 5*s*. (Dublin: Royal Dublin Society, 1955.) [181

Books for Young People. Group 1: Under Eleven, Annotated and Classified. Compiled by the North-Western Branch of the Library Association under the editorship of Hilda M. McGill. New edition, completely revised. Pp. 103. (London: Library Association, 1955.) 12*s*. (9*s*. to L.A. members.) [181

Department of Scientific and Industrial Research. Forthcoming International Scientific and Technical Conferences. List No. 18 (January 1956). Pp. 1+38. (London: Department of Scientific and Industrial Research, 1956.) [181

Royal Society for the Prevention of Accidents. Danger!—Office Staff at Work. Pp. 16. (London: Royal Society for the Prevention of Accidents, 1956.) 6*d*. [181

A Brief History of the Cambridge University Press. Pp. iii+26+3 plates. (Cambridge: At the University Press, 1955.) [181

Sperry Gyroscope Co., Ltd. Sperry Synchros (Publication No. 652.) Amendment No. 3. (Brentford, Mddx.: Sperry Gyroscope Co., Ltd., 1955.) [181

Republic of Ireland. Department of Agriculture: Fisheries Branch. Report on the Sea and Inland Fisheries for the year 1954, incorporating Statistics of the Capture of Salmon, Sea Trout and Eels. Pp. 47. (Dublin: Government Publications Sale Office, 1955.) 2*s*. 6*d*. [201

Association of Universities of the British Commonwealth. Report of the Executive Council, together with the Accounts of the Association for the year 1st August, 1954, to 31st July, 1955. Pp. 25. (London: Association of Universities of the British Commonwealth, 1955.) [201

Child Psychology. By Dr. Edna Balint. (Reader's Guides, Second Series, No. 4.) Pp. 24. (Cambridge: At the University Press, 1956. Published for the National Book League.) 2*s*. 6*d*. net. [201

Brompton Hospital Reports: a Collection of Papers by Members of the Staffs of the Hospitals for Diseases of the Chest (Brompton Hospital, London Chest Hospital) and of the Institute of Diseases of the Chest. Vol. 23, 1954. (London: Brompton Hospital, 1955.) 15*s*. [201

Other Countries

Geological Survey Department, Tanganyika. Bulletin No. 26: The Geology and Ecology of the Nachingwea Region: a reconnaissance survey of Topography, Soils, Vegetation and Geology in the Southern Province of Tanganyika. By Dr. D. R. Grantham, with contributions by R. D. Pilson. Pp. viii+33+3 plates+2 maps. (Dar-es-Salaam: Government Printer, 1955.) Shs. 7/50. [191

Records of the Queen Victoria Museum, Launceston. New Series, No. 3: The Occurrence in Tasmania of *Lactoria Diaphana* (Bloch and Schneider, 1801.) By Heather L. Jones. The Appearance of *Acridotheres tristis* Linne, in Northern Tasmania. By Heather L. Jones. Pp. 4. (Launceston: Museum Committee, Launceston City Council, 1955.) [191

Bulletin of the American Museum of Natural History. Vol. 107. Article 3: A Review and Revision of the Marlins, Genus *Makaira*, By Francesca R. Lamonte. Pp. 319–358+plates 4–12. (New York: American Museum of Natural History, 1955.) 1 dollar. [191

Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the year 1954. Pp. 10. (Observatory: The Observatory, 1955.) [191

Report of the President of the Carnegie Institution of Washington for the year ending June 30, 1955. Pp. 9. (Washington, D.C.: Carnegie Institution of Washington, 1955.) [191

Researches of the National Museum, Bloemfontein. Vol. 1, Part 7: A Revision of the Scaloposauridae with special reference to Kinetic in this Family. By A. W. Crompton. Pp. 149–184. Vol. 1, Part 8: Fossil Proboscidian Teeth and Ulna from Virginia, O.F.S. By A. J. D. Meiring. Pp. 185–202. (Bloemfontein: National Museum, 1955.) [191

The Commonwealth Fund. Thirty-seventh Annual Report for the year ending June 30, 1955. Pp. vii+46. (New York: Commonwealth Fund, 1955.) [191

United States Department of Commerce: National Bureau of Standards. Circular 539: Standard X-ray Diffraction Powder Patterns. By Howard E. Swanson, Nancy T. Gilfrich and George M. Ugrinic. Pp. ii+75. (Washington, D.C.: Government Printing Office, 1955.) 45 cents. [191

Union of South Africa: Department of Mines. Geological Survey Memoir 46: The Geology and Mineral Deposits of the Potgietersrus Tin-Fields. By C. A. Strauss. Pp. x+252+49 plates+13 folders. (Pretoria: Government Printer, 1954.) 20*s*. [191

Smithsonian Miscellaneous Collections. Vol. 126, No. 1: The Bromeliaceae of Brazil. By Lyman B. Smith. Pp. vii+290. (Publication 4184.) (Washington, D.C.: Smithsonian Institution, 1955.) [191

East Africa High Commission. East African Industrial Research Organization Annual Report, 1954–55. Pp ii+17. (Nairobi: East African Industrial Research Organization, 1955.) [191

Inter-American Tropical Tuna Commission. Annual Report for the year 1954. Pp. 100. (La Jolla, Calif.: Inter-American Tropical Tuna Commission, 1955.) [191

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Technique No. 46: Le Débit des Bois a la Scie a Ruban. 1: Introduction a l'Étude du Sciage des Principaux Bois du Congo Belge. Par R. C. Antoine et L. E. Laloyaux. Pp. 31. 25 francs. Série Technique No. 47: Le Débit des Bois a la Scie a Ruban. 2: Étude du Sciage de *Chlorophora Excelsa* (Kambala, Mulundu). Par R. C. Antoine et L. E. Laloyaux. Pp. 77. 60 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1955.) [191

The Recent Genera of the Carodean and Stenopodidean Shrimps (Class Crustacea, Order Decapoda, Supersection Natantia), with Keys for their Determination. By L. B. Holthuis. (*Zoologische Verhandelingen*, No. 26.) Pp. ii+157. (Leiden: E. J. Brill, 1955.) [191

Publicazioni dell'Universita Cattolica del S. Cuore. Nuova Serie, Volume 48. Contributo del Laboratorio di Psicologia, Serie 18. Pp. v+426+21 plates. 7000 lire. Nuova Serie, Volume 49. Contributo del Laboratorio di Psicologia, Serie 19. Pp. v+540. 7000 lire. (Milano: Società Editrice "Vita e Pensiero," 1955.) [191

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 36, No. 11: The Seasonal Variation in Disability. Pp. 12. Cumulative Index to the Statistical Bulletin of the Metropolitan Life Insurance Company, Volumes 26–35, 1945–1954. Pp. 17. (New York: Metropolitan Life Insurance Co., 1955.) [191

East Africa High Commission. Annual Report of the East African Agricultural and Fisheries Research Council, 1954–55. Pp. ii+84. (Nairobi: Office of the Administration, E.A. High Commission, 1955.) 3*s*. [191

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 34, No. 32: A New Species of Chondria with a Key to the Bornean Species (Coleoptera: Endomychidae). By H. F. Strohecker. Pp. 331–332. 10 cents. Vol. 34, No. 33: Three New Bulbuls from Africa (Class Aves). By Austin L. Rand. Pp. 333–336. 10 cents. Fieldiana: Botany. Vol. 24, Part 2: Flora of Guatemala. Part 2: Grasses of Guatemala. By Jason R. Swallen. Bamboos. By F. A. McClure. Pp. ix+390. 6 dollars. (Chicago: Chicago Natural History Museum, 1955.) [191

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East Africa High Commission. East African Medical Survey and Research Institute Annual Report, 1954–1955. Pp. 1+44. (Nairobi: Government Printer, 1955.) [191

United States Department of Agriculture. Circular No. 967: Overwintering, Spring Emergence and Host Synchronization of Two Egg Parasites of the Beet Leafhopper. By Chas. F. Henderson. Pp. 10. 15 cents. Circular No. 968: Parasitization of the Beet Leafhopper in Relation to Its Dissemination in Southern Idaho. By Charles F. Henderson. Pp. 16. 15 cents. Technical Bulletin No. 1124: Gypsy Moth: Appraisal Program and Proposed Plan to Prevent Spread of the Moths. By C. C. Perry. Pp. 27. 15 cents. Leaflet No. 391: The Southern Corn Rootworm: How to Control It. Pp. 8. 5 cents. (Washington, D.C.: Government Printing Office.) [201

Annuario del Observatorio Astronómico de Madrid, para 1956. Pp. 503. (Madrid: Talleres del Instituto Geográfico, 1955.) 50 pesetas. [201